Report on British Fossil Reptiles. By Richard Owen, *Esq., F.R.S., F.G.S., &c. &c.*

Part II.

The British Fossil Reptiles described in the first part of this Report presented modifications of their osseous structure, and especially of the vertebral column and locomotive extremities, by which they were especially adapted for a marine life, and hence have been collectively termed *Enaliosauria*. All the numerous species of this family are extinct, and it seems that the genera have ceased to be represented since the deposition of the chalk formations. In the present zoological systems the *Plesiosauri* and *Ichthyosauri* are referrible to the Saurian order of reptiles, as defined by Cuvier; but they offer the most remarkable deviations from the existing types, and constitute links which connect the Reptiles, on the one hand, with Fishes, and, on the other hand, with the cetaceous Mammals.

The present and concluding part of the Report on British Fossil Reptiles contains an account of the remains of the Crocodilian, Dinosaurian, Lacertian, Pterodactylian, Chelonian, Ophidian and Batrachian reptiles.

The most remarkable of the extinct species of the amphibious and terrestrial *Sauria* of England have been discovered and described by Dr. Buckland and Dr. Mantell. Some remains are briefly noticed by Parkinson*, and by the older English observers, as Wooller and Chapman. Cuvier has added to the value of these discoveries by his just observations and comparisons. Some of the British Chelonian fossils have been noticed by Parkinson, Cuvier and Dr. Mantell; but none of the British extinct Ophidians or Batrachians appear to have been hitherto recognized as such.

Pliosaurus.

The Enaliosaurs are immediately connected with the Crocodilian reptiles by an extinct genus, represented by species of gigantic size, of which the remains are not unfrequent in the Kimmeridge and Oxford clays. The Reptile in question is essentially a modified *Plesiosaurus*, but its modifications appear to entitle it to be regarded as a distinct genus, which, as it is more closely allied to the true Sauria, I have proposed to call *Pliosaurus*†.

Large, simple, conical teeth, with the enamelled crown traversed by well-defined and abruptly terminated longitudinal or oblique ridges, as in the teeth of the Plesiosaur, have not unfrequently been discovered in the Kimmeridge clay formation. These teeth differ from those of the Plesiosaur in their greater relative thickness as compared with their length, and in the subtrihedral shape of their crown; the outer side is slightly convex, sometimes nearly flat; it is separated from the two other sides by two sharp ridges; these are more convex, and the angle dividing them is often so rounded off that they form a demi-cone, and the shape of the tooth thus approximates very closely to that of the Mosasaur, with which it is equal in size. It may be readily distinguished, however, even when the crown only is preserved, by the ridges which traverse the inner or convex sides, the outer flattened surface alone being smooth; but an entire tooth of the present extinct Reptile presents a long fang, which at once removes it from the acrodont group of lacertine Saurians, and allies it with the thecodont Reptiles, among which it approaches nearest, in the superficial markings of the crown, to the Plesiosaur.

The known parts of the skeleton of the gigantic extinct reptile, to which the teeth in question belong, confirm this approximation; but the vertebræ of the

* Organic Remains of a Former World, vol. iii.

† Odontography, Part II., p. 282.

neck are so modified, that the peculiarly elongated proportion of this part of the spine, which characterizes the typical Plesiosaurs, is exchanged for one that much more nearly approaches the opposite condition of the cervical region in the Ichthyosaurs. This abrogation of the main characteristic of the Plesiosaurs, combined with the more crocodilian proportions of the teeth, establishes the claims of the *Pliosaurus* to generic distinction.

In the collection of Professor Buckland, at Oxford, is preserved a considerable proportion of both the upper and lower jaws of a gigantic specimen of the *Pliosaurus*, from the Kimmeridge clay formation at Market-Raisin. The teeth are arranged in separate sockets, in a close and regular series, along the alveolar borders of the intermaxillary, maxillary and premandibular bones. Twenty-six sockets may be counted on the most perfect side of the upper jaw; but the series is evidently incomplete posteriorly. An interspace, not quite equal to the breadth of a socket, divides the fourth from the fifth tooth, counting backwards, and the jaw is slightly compressed at this interspace; the four anterior teeth, thus marked off, occupy the slightly expanded anterior extremity of the upper jaw, but do not present the excessive size of the corresponding teeth in the Plesiosaur. After the fifth tooth the sockets progressively increase in size to the twelfth tooth, and from the fourteenth they begin gradually to diminish in size, becoming, beyond the twentieth tooth, smaller than those at the fore part of the jaw.

The alveolar septa are narrow, and are thinned off to an edge, which is lower than either the outer or inner walls of the sockets: these walls are equally developed. A line drawn transversely across any of the twelve anterior sockets would be transverse to the jaws, but in the remaining sockets it would incline obliquely from without, inwards and backwards. The transverse diameter of the thirteenth socket is one inch six lines; its antero-posterior diameter is one inch eight lines.

The extent of the alveolar series in both jaws is nearly three feet; the breadth of the palate at the twenty-sixth tooth is nearly one foot; the breadth of the upper jaw at the third tooth is four inches and three lines; the breadth of the socket of that tooth is one inch three lines.

In the lower jaw of the specimen in the Oxford Museum, the posterior extremity of the dental series is complete, but not the anterior one; thirty-five teeth are present in each premandibular bone. The first, from its large size, I conclude to have been received into the slight concavity at the side of the upper jaw, where the diastema separates the fourth and fifth teeth; there are probably, therefore, thirty-eight teeth on each side of the lower jaw. Counting backwards, on this supposition, the teeth begin to diminish in size beyond the fifteenth, and at the posterior extremity of the series the sockets are less than half an inch in diameter: in their close arrangement and position they correspond with those of the upper jaw.

The teeth which are preserved in this magnificent cranial fragment, present the characters above defined. The inserted fangs of most of these teeth are four inches in length; the entire tooth being thus seven inches in length. The ridges which divide the outer from the inner surfaces of the tooth subside at the base of the crown; the fang is smooth; it assumes a subcircular form, gradually expands for about half its length, and then contracts to its termination; but this is always less pointed than in the fully formed teeth of the true Plesiosaur. In the old teeth with the elongated fang, the pulp cavity remains open, as in the Plesiosaurian teeth; it presents at the expanded part of the fang a narrow elliptic transverse section. In a tooth of the present species, six inches and a half in length from the Kimmeridge clay at Shotover, the diameter of the persistent pulp-cavity was thirteen lines. In this tooth

the flattened surface is polished, but marked with minute shallow wrinkles; one of the ridged surfaces, which stood at right angles to the preceding, was traversed by eleven well-marked linear ridges of unequal length, separated by smooth interspaces of about three times the breadth of the ridges; the third surface, which formed an acute angle with the smooth outer surface, was traversed by twelve ridges. These ridges, on the inner surface of the tooth, slightly inclined towards the rounded angle, dividing the surfaces; they terminate abruptly; some cease half way from the apex of the crown; about ten are continued to within half an inch of the apex, which is smooth; the two ridges, which divide the flat or smooth side from the ridged surfaces of the tooth, are alone continued to the subacute apex of the tooth.

The teeth of the Pliosaur present varieties of form as well as of size; the rounding off of the angle between the ridged surfaces has been already alluded to; the smooth outer surface is sometimes so convex, that the transverse section of the tooth is more elliptical than triangular. All the teeth of the Pliosaur are slightly bent inwards and backwards; but the smaller posterior teeth are most recurved, and have the sharpest apex; and in the crown of these teeth the ordinary rounded or elliptical form of the cone is most nearly attained; but the distinction of the smooth external surface, and the ridged internal surfaces of the crown of the tooth are retained, and would suffice to characterize any of these teeth if found detached.

The teeth consist of a central body of compact dentine, with a coronal investment of enamel, and a general covering of cement. The dentine is permeated by fine calcigerous tubes, without admixture of medullary canals. The arrangement, division, secondary undulations, and branches of the calcigerous tubes closely correspond with those of the teeth of the Plesiosaur. The germs of the successional teeth in the Pliosaur were developed at the inner side of the basis of the old teeth, but did not penetrate these teeth; the apices of the new teeth make their appearance through foramina situated at the inner side, and generally at the interspaces of the sockets of the old teeth. Here, therefore, as perhaps also in the Pterodactyle, the growing teeth may be included in closed recesses of the osseous substance of the jaw, and emerge through tracts distinct from the sockets of their predecessors, which is an exceptional condition of the reproduction of the teeth in reptiles.

Of the Vertebral Column.—A long neck has been considered to be so peculiarly the distinction of the Plesiosaur, that a species which has this part of the spine shortened and reduced by the flattening of the vertebræ to Ichthyosaurian proportions, may be reasonably regarded as at least subgenerically distinct, especially when the enormous and massive head, to which the abbreviated neck bears a subordinate relationship, is armed with teeth which have just been shown to be as remarkable for their thickness and strength as those of the Plesiosaurus are for their slender and sharp-pointed proportions.

Perhaps there is no example, save the genus *Pliosaurus*, in the whole class of reptiles, living or extinct, which has any of the vertebræ presenting such proportions as those of the following specimen in Dr. Buckland's collection from the Kimmeridge clay of Foxcombe Hill, near Oxford. The breadth of the body of this vertebra is six inches; its depth, or vertical diameter, five inches; while in length, or the diameter corresponding with the axis of the body, it measures only an inch and a half. But cervical vertebræ of similar proportions have been discovered in the Kimmeridge clay near Weymouth, and were described by Mr. Conybeare in the 'Geological Transactions.' The Market-Raisin specimen in the Oxford Museum proves that those peculiarly compressed vertebræ are associated with the well-defined teeth characteristic of the Oxford and Kimmeridge clays, and with jaws of great size, which could

only be supported and wielded by a neck as short and strong as in the Cetaceous inhabitants of the sea.

The cervical vertebræ, as they recede from the head, increase in breadth and depth, but retain the same length, as they do throughout the spine in most Saurians, whatever may be their other dimensions. But in the dorsal region of the spine of the Pliosaur, the vertebræ acquire a great increase of length, and there assume the ordinary proportions of Plesiosaurian vertebræ: for example, the first dorsal vertebra of the Market-Raisin specimen, which is four inches three lines in breadth, and four inches in depth, measures nearly three inches in length. The posterior dorsal vertebræ slightly increase in depth, and with the same transverse diameter they present a length of 3 inches 2 lines. The height of one of these vertebræ, including the spinous process, is 11 inches. These proportions are retained at least to the base of the tail. A vertebra from this part, obtained from St. Giles's gravel-pit, near Oxford, and probably washed out of the Kimmeridge clay, measures in length 3 inches; in the breadth of the body, 4 inches 9 lines; in the depth of the same, 4 inches 4 lines.

In the extreme difference which the vertebræ of the neck and those of the rest of the trunk present in regard to their length, the *Pliosaurus* forms a remarkable exception to Saurians in general; for in the true Enaliosaurs, in Crocodiles, in Lizards, whatever other modifications the vertebræ may undergo, or however much they may be expanded in breadth or depth, they maintain great constancy in the length or antero-posterior diameter of the body. The Pterodactyles, or flying-lizards, offer another exception to this rule, and the cervical region is here likewise the seat of the variation; but whereas in the Pliosaur the cervical vertebræ are remarkable for their shortness; in the Pterodactyle they differ from the other vertebræ in their extreme length.

The general structure of the vertebræ of the Pliosaur corresponds closely with that of the Plesiosaur. The osseous texture is compact at the circumference of the vertebræ, and coarsely, but uniformly, cellular in the rest of the bone. The neurapophyses do not become anchylosed to the centrum, nor the ribs to the costal processes. The articular surfaces at each end of the centrum are flat in the cervical, very slightly concave in the dorsal, rather more concave in the caudal vertebræ. The cervical ribs, judging from their articulation with the centrum, must have been unusually strong. The rib on each side of the vertebra was supported on two transverse processes, slightly raised beyond the level of the centrum, occupying two-thirds of its antero-posterior extent, and divided by a deep and well-marked linear fissure. In the anterior cervical vertebræ above described, with a length of 1 inch 9 lines, and a height of centrum of 3 inches 3 lines, the antero-posterior diameter of the constant surfaces was 1 inch 2 lines; their united vertical diameter, 2 inches 2 lines. They occupy a space nearly equi-distant from the upper and lower surfaces of the centrum. At the base of the neck they begin to rise, as in the Plesiosaur, upon the neurapophysis, and are supported, in the dorsal region, upon a single stout transverse process. This is subdepressed, with an oval transverse section, which is rather sharp at the anterior margin. The spinous process of the dorsal vertebræ is nearly straight, compressed laterally; its antero-posterior diameter was 2 inches 8 lines; in a vertebra, measuring in the same diameter 3 inches 2 lines, its height from the base of the neurapophysis was 7 inches. The sides of the centrum are rather rugous near the articular ends, elsewhere smooth and concave, especially in the dorsal vertebræ. The lower surface has the two vascular perforations in the cervical regions; the vertebræ become slightly contracted towards this part in the dorsal region. In the caudal vertebræ the costal process is single, vertically elliptical, and

prominent. The non-articular surface of the centrum is not very regular, but is smooth; the lower surface is square-shaped, and nearly flat; its angles are marked by the hæmapophysial surfaces, of which the anterior pair is the largest.

Bones of the Extremities.—The type of construction of the bones of the extremities closely accords with that of the Plesiosaur. The pectoral arch owes its chief strength to a pair of immensely expanded coracoids, having a broad and short entosternal bone on their anterior interspace, and supporting the clavicles, or the acromial productions of the scapulæ.

The femur of the Market-Raisin specimen measures two feet two inches in length, and is thirteen inches broad at its distal end—a bone well fitted to support and wield the strong paddle that must have been mainly instrumental in propelling this carnivorous sea-monster through its native element.

In another femur, measuring thirteen and a half inches across the distal end, the circumference of the proximal end was nearly two feet; the upper half of the bone is cylindrical; it gradually exchanges this for a compressed expanded distal end, which is terminated by a pretty regular convex curve. The texture of the bone is coarsely cellular throughout, being devoid, as in other marine Saurians, of any trace of medullary cavity.

One of the subcircular carpal bones of the Market-Raisin specimen measured five and a half inches across the broadest part, and four and a half across the narrowest, and was two and a half inches in thickness.

The phalanges are short and less compressed than in the Plesiosaurs; flat at the articular extremities, and remarkably contracted in the middle.

Besides the localities affording specimens from which the general description of the bones of the trunk and extremities is taken, and which localities are noticed in that description, remains of the Pliosaur have been discovered in the following localities:—A small cervical vertebra from Shotover, in the Oxford Museum; four dorsal vertebræ, equal in size with the Market-Raisin specimen, from Marcham, also in the Oxford Museum; the vertebra in the Yorkshire Museum*, said to have been found in the gravel of Burn, one mile below Nunnykirk, Northumberland, and noticed in the first edition of Lyell's 'Principles of Geology,' is a posterior cervical of a *Pliosaurus*, and must be presumed to have been accidentally introduced into that recent deposit. The several specimens from these different localities yield strong indications of two distinct species of the present gigantic genus, which connects the Enaliosaurs with the Cœlospondylian Crocodiles. The difference in breadth and height, and especially in the size of the hatchet-bone, or cervical rib, as indicated by the articular surface, appear to be inexplicable, except on the supposition of two distinct species. The difference is continued in the dorsal vertebræ, the transverse processes of which are more compressed, and the non-articular surface more rugous in the Shotover than in the Market-Raisin species. The two forms of femora, on which the species *Plesiosauri grandis* and *trochanterius* are founded in the former part of this Report, are both referable to the genus *Pliosaurus*; but have not as yet been found so associated with vertebræ as to aid, in combination with the vertebral characters, in the definition of the two species. When subsequent discoveries and observations shall have supplied distinct and recognizable characters to the two species of the present very remarkable and interesting annectant genus, the term *brachydeirus*, which I had first proposed for the species represented by

* In the Yorkshire Museum there is preserved a humerus of a Pliosaur from the lower part of the Kimmeridge clay deposit at Speaton, which measures thirteen inches in length, and seven inches across the distant end: the femur of the same specimen measured sixteen inches in length.

the magnificent remains from Market-Raisin*, would be equally applicable to the short-necked gigantic Pliosaur from Shotover, and consequently lose its value as a distinctive appellation.

CROCODILIA.

The remains of species of this order extend from the Eocene tertiary formations as low down as the Oolite and Lias, and offer deviations from the structure of the existing genera and species, which increase in degree and amount as the strata containing the extinct species indicate periods more remote from the present time.

Not any of the species are identical with those now known to exist, and the modifications of the osseous structure, by which the extinct Crocodilians differ both from the present races and from one another, are much greater than any of those by which the skeletons of the existing species differ among themselves. Not only do the form and proportions of the peripheral parts, as of the jaws, the teeth, and the locomotive extremities vary, but the spine, or central axis of the skeleton, offers modifications of the articular surfaces of the component vertebræ which are quite unknown in the Alligators, Crocodiles and Gavials of the present epoch. In these existing species the anterior surface of the vertebral centrum is concave, the posterior convex, except in the atlas and sacrum. But besides this mode of junction, Cuvier has recognized in the Crocodilians of the secondary formations two other types of vertebral structure: in one of these the positions of the ball and socket are reversed; in the other, and more common modification, both articular surfaces of the vertebra are flat or slightly concave. Remains of extinct Crocodilians, exhibiting all the three systems of vertebral articulation, occur in English formations. The extinct species, which agree with the existing Crocodilians in their vertebral characters, will be first described.

a. With concavo-convex Vertebræ.

Crocodilus Spenceri, Buckland.

'*Crocodile de Sheppy*,' Cuv.

The most recent stratum in which I have met with the remains of extinct Crocodiles in Great Britain is the Eocene deposit called the London clay†. A third cervical vertebra from the Isle of Sheppy, is noticed by Cuvier as being very similar to the corresponding bone in an existing Crocodile, and as having appertained to an individual of probably five feet in length. No other part of this Eocene reptile is noticed in the last edition of the 'Ossemens Fossiles‡.' A fine cranium is preserved in the British Museum; and Dr. Buckland§ has figured a smaller but better preserved specimen of the Sheppy Crocodile, in the collection of E. Spencer, Esq. I have examined both these specimens, and have compared them with the skulls of the recent Crocodilians.

In Mr. Spencer's fossil, the end of the snout, including the intermaxillaries and nostrils, is broken off; the tympanic pedicles, pterygoid alæ and occipital tubercle, and the crown of the teeth are also wanting. The principal and most characteristic differences which the *Crocodilus Spenceri* presents in

* Odontography, p. 283.

† Cuvier makes mention of the calcaneum of a Crocodile in the collection of M. G. A. Deluc, said to have been discovered at Brentford in the year 1791, associated with the remains of the Mammoth, Hippopotamus, Rhinoceros and Deer, and which bore incontestable marks of a distinct species. He observes that if this bone had not been transported to its present situation, with the debris of other strata, it would be the most recent of the remains of the genus of Crocodile.—*Loc. cit.*, p. 336, vol. ix.

‡ 8vo, 1836, vol. ix. p. 327.

§ Bridgewater Treatise, vol. i. p. 251, pl. xxv. fig. 1.

reference to the *Crocodilus biporcatus*, or other existing species of Crocodile or Alligator, are the larger size of the temporal holes as compared with the orbits, the more regular and rapid diminution of the head towards the snout, the straight line of the alveolar tract, and the greater relative length and slenderness of the muzzle, which is evident notwithstanding its imperfect condition. These differential characters are equally manifest in the larger, and in some respects more perfect specimen, of the cranium of this species in the British Museum.

Amongst existing Crocodiles, the Bornean species, called *Crocodilus Schlegelii*, most resembles the *Crocodilus Spenceri*. But in the Sheppy Crocodile the posterior smooth surface of the occiput is less concave; its upper boundary line is indented in the middle by the termination of a median longitudinal depression upon the upper surface of the skull, which is not present in the existing species, in which the corresponding surface is flat. The descending process of the basi-occipital, below the articular tubercle, is smoother in the *Crocodilus Spenceri*; the interorbital space is flatter: the upper temporal foramina equal the orbits in size—a character by which the *Crocodilus Spenceri* manifestly approaches the Gavials. The nasal and superior maxillary bones are smoother; the sloping profile line of the face is straighter, and the lateral converging lines of the upper jaw are straight. These characters are well shown in the British Museum specimen.

The upper jaw slightly expands about one-third from its termination, then contracts, and again expands at the muzzle. At this anterior part the bones are more pitted than they are nearer the cranium. The alveolar margin seen in the whole skull is slightly undulating. The jugal bone is slender and nearly horizontal. The lower jaw has a large elliptical vacuity at its expanded posterior part. Its alveolar risings correspond with the sinkings of the same part in the upper jaw. In all these characters it corresponds with the *Crocodilus Schlegelii* of S. Müller.

Upon the lower surface of the skull the pterygoids in the *Crocodilus Spenceri* are terminated anteriorly by a broader and straighter transverse line; from the middle of which the palatines are continued, their posterior extremities not being expanded, as in the *Crocodili vulgaris* or *biporcatus*, but of the same breadth as the rest of the bone. The anterior and internal curved border of the transverse bones is more regular. The dental series terminates posteriorly nearer the anterior part of the transverse bone. The teeth, $\frac{22-22}{20-20} = 84$, are more uniform in size, and more regularly spaced; the intervals, however, vary from $1\frac{1}{2}$ to 2 and 3 lines; and that between the first tooth in Mr. Spencer's mutilated specimen and the second equals 7 lines. The diameter of the base of the crown of the tooth is 3 lines: there are nine of these teeth in the same extent as that which includes eleven teeth in a specimen of the *Crocodilus vulgaris*, having a skull of similar breadth. The teeth in the *Crocodilus Spenceri* are subcircular, with an anterior and posterior longitudinal ridge, with intervening fine longitudinal striæ.

The sculpturing of the cranial bones is very similar in the recent and fossil Crocodiles, but the facial bones are smoother in the *Crocodilus Spenceri*, as they likewise seem to be in the *Crocodilus Schlegelii*.

The following dimensions are taken from the skull of the *Crocodilus Spenceri* in the British Museum:—

	Ft.	In.	Ln.
Length of cranium from the lower end of the tympanic bone to the beginning of the nostril	2	0	0
Breadth of ditto between the articular end of the tympanic bones	0	10	0
From the articular end of the tympanic to the orbit	0	8	6

	Ft.	In.	Ln.
From the orbit to the nostril	0	14	6
Breadth of the cranium across the orbits	0	7	6
Ditto five inches in advance of orbit	0	3	8
Ditto across the first expansion of the jaw	0	4	0
Ditto across the nostril	0	2	8
Depth of lower jaw at the posterior vacuity	0	3	6
Length of the vacuity	0	3	0
Breadth of the base of a tooth at the first expansion	0	0	8

In the museum of Fr. Dixon, Esq., at Worthing, there is a fine fossil, referable to the *Crocodilus Spenceri*, from the Eocene clay of Bognor. It consists of a portion of the skeleton, including the lumbar, sacral, and five of the caudal vertebræ, in a continuous chain of ten inches in length, but bent in an abrupt curve.

The vertebræ, as compared with those of the *Crocodilus acutus*, have the sides of the centrum deeper or more extended vertically, and they are slightly concave; the first caudal is, as usual, bi-convex, the under surface is rather flattened. The femur presents the usual sigmoid curve, it has a well-marked medullary cavity; its length is five inches six lines. Mr. Dixon possesses, from the same locality, a posterior cervical vertebra of a Crocodile, similar in general characters to those just described, but larger, and probably belonging to an older individual. The length of the body of this vertebra is two inches and a half.

Remains of Crocodilians occur in the London clay at Hackney, and in the Eocene sand-beds at Kyson, in Suffolk; I have seen from this locality small bifurcate finely-striated conical teeth, and a small bony scutum, with regular and pretty deep pits, about the size of pins' heads.

β. With biconcave Vertebræ.

Suchosaurus cultridens.

Gavial of the Tilgate Forest, Mantell. (?)

Teleosaurus ——, H. v. Meyer.

I next proceed to notice the fossil Crocodiles from the more recent secondary formations, and shall commence with those species with biconcave vertebræ, the remains of which are characteristic of the Wealden beds.

Amongst the evidences of Crocodilian Reptiles which are scattered through the Tilgate strata the most common ones are detached teeth, from the difference observable in the form of which, Dr. Mantell has observed, that "they appear referable to two kinds; the one belonging to that division of Crocodiles with long slender muzzles, named *Gavial*; the other to a species of *Crocodile*, properly so-called, and resembling a fossil species found at Caen *."

Dr. Mantell has obligingly communicated to me figures of well-preserved specimens of both the forms of teeth alluded to, the exactness of which I have recognized by a comparison with the specimens themselves in the British Museum.

The tooth which, from its more slender and acuminated form, approaches nearest to the character of those of the Gavial, differs from the teeth of any of the recent species of that sub-genus of Crocodilians, as well as from those of the long and slender-snouted extinct genera, called *Teleosaurus*, *Steneosaurus*, &c. I have described this form of tooth †, therefore, as indicative

* Wonders of Geology, 1839, vol. i. p. 386.

† Odontography, pl. lxii. A, figs. 9 and 10.

of a distinct species, under the name of *Crocodilus cultridens**. The crown is laterally compressed, subincurved, with two opposite trenchant edges, one forming the concave, the other the convex outline of the tooth. In the Gavial, the direction of the flattening of the crown and the situation of the trenchant edges are the reverse, the compression being from before backwards, and the edges being lateral†. The tooth of the *Crocodilus cultridens* thus resembles in form that of the Megalosaur, and perhaps still more those of the Argenton Crocodile; but I have not observed any specimens of the Wealden teeth in which the edges of the crown were serrated, as in both the reptiles just cited. The teeth of the *Crocodilus cultridens* also present a character which does not exist in the teeth of the Megalosaur, and is not attributed by Cuvier‡ to those of the *Crocodile d'Argenton*. The sides of the crown are traversed by a few longitudinal parallel ridges, with regular intervals of about one line in breadth, in a crown of a tooth one inch and a half in length: these ridges subside before they reach the apex of the tooth, and sooner at the convex than at the concave side of the crown.

Hitherto these teeth have not been found associated with any part of the skeleton of the present extinct Crocodilian; but from the well-marked differences between these teeth and those of all other known species, it is most probable that the extinct Crocodile formed the type of a distinct sub-genus, for which the term *Suchosaurus* might be applied.

In the Wealden strata, biconcave Crocodilian vertebræ have been discovered by Dr. Mantell differing in form from those of the Crocodilian with obtuse teeth, and readily distinguishable by their compressed and wedge-shaped body from those of all other known Crocodilians. It is highly probable that these remarkable vertebræ are parts of the same animal as the above described and equally remarkable compressed teeth.

No. $\frac{138}{2138}$, Mantellian Collection, is the body of a dorsal vertebra of this species of Crocodilian, with both articular extremities slightly and equally concave: though rather narrower at the middle than at the ends, it is more uniformly compressed than in other Crocodilian vertebræ, the sides converging to an inferior obtuse ridge, which is very slightly concave in the antero-posterior direction. The sides are not flat in the vertical direction nor slightly concave, as in many of the *Iguanodon's* vertebræ, to which the present form approximates; but are gently convex, so that a pencil laid vertically upon the side touches it only by its middle. A more decided difference between the present crocodilian vertebræ and those of the *Iguanodon* is, that the former are longer in proportion to their height and depth. The external surface at the middle of the body of the vertebra is very finely striated, so as to present a silky appearance; near the margins it is sculptured by coarse longitudinal grooves and ridges.

The base of the neurapophysis, which, when anchylosed, leaves an evident trace of the suture, is nearly equal in length with the body of the vertebra; it does not wholly include the spinal canal, but leaves the impression of the lower third of that canal upon the upper surface of the centrum.

* These teeth are referred by M. H. v. Meyer to the genus *Teleosaurus*; but no portions of the skeleton of a Teleosaur have hitherto been found in the Wealden. The figures of the teeth of *Suchosaurus cultridens*, published by Dr. Mantell in the 'Illustrations of the Geology of Sussex,' pl. v. fig. 5, 6, 8, are those cited in the 'Palæologica,' p. 115. The other teeth attributed to the same species of *Teleosaurus*, by H. v. Meyer, out of Mantell, *l. c.* pl. v. figs. 1, 2, 7, 9, 10, 11, appertain to a genus equally distinct from *Suchosaurus* and from *Teleosaurus*.

† The tooth attributed by M. Deslongchamps to the *Poikilopleuron*, agrees in form with those of the Gavial, and differs in the characters cited in the text from those of the *Crocodilus cultridens*.

‡ Cuvier, ix. p. 331.

In No. $\frac{123}{2123}$, Mantellian Collection, the bases of the neurapophysis remain attached to the centrum, which presents the same characters as No. $\frac{138}{2138}$. On the outside of the neurapophysis are two slightly developed broad obtuse ridges, converging towards each other from the outer side of each angle or end of the base of the neurapophysis; the ridge corresponding with the posterior of these in the *Iguanodon's* vertebra rises more vertically, and is in higher relief.

The neurapophysial suture slightly undulates in its horizontal course, and rises in the middle instead of descending upon the centrum, as in the Plesiosaurs.

The present vertebra is alluded to at p. 70, and figured at pl. ix. fig. 11, of Dr. Mantell's 'Illustrations of the Geology of Sussex,' as a lumbar vertebra of the *Megalosaurus*. But in the 'Geology of the South-east of England,' the accomplished author, speaking of this vertebra, observes, "It cannot, I now think, be separated from those figured in the same plate, as belonging to a crocodile."—p. 297. Fig. 8, pl. ix, (Tilgate Fossils) is, however, a caudal vertebra of the *Cetiosaurus*. As I have examined with care the original vertebra of the *Megalosaurus*, figured after Buckland, and referred to by Dr. Mantell at pl. xix. fig. 16 of the same work, I can attach the greatest confidence to the following differences:—the body of the Megalosaurian vertebra has a pretty deep longitudinal depression below the neurapophysial suture, wanting in the Tilgate vertebra here described. This, however, is not the only distinction; below the depression the body of the Megalosaurian vertebra swells out, and is as convex below as it is laterally in the transverse direction, so that the outline of a transverse section would describe five-sixths of a circle: a similar section of No. 123 would be triangular with the apex rounded off. The Megalosaurian vertebra is more contracted at the middle, and swells out near the articular ends, surrounding those articulations with a thick convex border: in No. 123 the lateral meet the marginal surfaces at a somewhat acute angle; but the silky striated surface of the Crocodilian vertebra, and the smooth and polished surface of the Megalosaurian one, would effectually serve to distinguish even fragments from the middle of the body of each.

The following are dimensions of the two vertebræ of the large Wealden Crocodilian above described:—

	No. 123.		No. 138.	
	In.	Lines.	In.	Lines.
Antero-posterior diameter of the body . . .	3	4	3	10
Vertical diameter of its articular end	2	5	3	2
Transverse diameter of its articular end . . .	2	10	2	9
Transverse diameter of the middle of the body	2	0	2	0

GONIOPHOLIS CRASSIDENS, O.

Swanage Crocodile, Mantell.

Teleosaurus ——, H. v. Meyer.

The second form of tooth having the generic characters of those of the Crocodile, which has been discovered in the Wealden and approximate strata, is as remarkable for its thick, rounded and obtuse crown as the teeth of the preceding species are for their slender, compressed, acute and trenchant character. It consequently approaches more nearly to the teeth which characterize the broad and comparatively short-snouted Crocodiles; but it differs from these in one of the same characters by which the tooth of the *Suchosaurus cultridens* differs from those of the Gavials, viz. in the longitudinal ridges which traverse the exterior of the crown. These are, however, more

numerous, more close-set, and more neatly defined than in the *Suchosaurus cultridens*. Two of the ridges, larger and sharper than the rest, traverse opposite sides of the tooth, from the base to the apex of the crown; they are placed, as in the Crocodile and Gavial, at the sides of the crown, midway between the convex and concave lines of the curvature of the tooth. These ridges are confined to the enamel; the cement-covered cylindrical base of the tooth is smooth. The size of the teeth varies from a length of crown of two inches, with a basal diameter of one inch and a half to teeth of one-third of these dimensions.

Hitherto no teeth of the *Goniopholis* appear to have been discovered in the oolite near Caen; the only specimens resembling them being those which Cuvier has stated to indicate a second species of Crocodilian, from the Jura limestone at Soleure*. No other remains referable to this species are noticed by Cuvier; but the discovery of a portion of the skeleton, having in the lower jaw two teeth identical with the obtuse teeth of the Wealden, has thrown much light upon the characters of this interesting species.

The circumstances connected with this discovery are thus narrated by Dr. Mantell:—"In the summer of 1837, the workmen employed in a quarry in the immediate vicinity of Swanage, had occasion to split asunder a large slab of the Purbeck limestone, when, to their great astonishment, they perceived many bones and teeth on the surfaces they had just exposed. As this was no ordinary occurrence,—for although scales of fishes, shells, &c. were frequently observed in the stone, bones had never before been noticed,—both slabs were carefully preserved by the proprietor of the quarry." They were obtained by Robert Trotter, Esq., F.G.S., and presented by him to Dr. Mantell, by whom the bones were relieved from the matrix, so far as their brittle state would permit. The specimen has subsequently been purchased by parliament, and, with the rest of Dr. Mantell's collection, is now deposited in the British Museum.

Figures of this interesting group of bones have been published by Dr. Mantell in his 'Wonders of Geology,' vol. i. pl. i.; but, excepting the remark above quoted, with regard to the nearer approach which the fossil makes in the form of its teeth to the sub-genus *Crocodilus*, as compared with the more slender Wealden tooth, no other observation has been published which tends to establish more precisely and closely the true affinities and nature of the Swanage Crocodilian.

The first character which attracts attention is that which the numerous, large, bony, dermal plates or scutes afford. These are scattered irregularly over the slab, and in their number and relative size bring the species much nearer to the extinct Teleosaurs than to any of the existing Crocodiles; they differ, however, from both the dorsal and ventral scutes of the Teleosaur in their more regular quadrilateral figure; they are longer in proportion to their breadth than most of the Teleosaurian scutes, and are distinguished from those of all other Crocodilians, recent and fossil, that I have yet seen, by the presence of a conical, obtuse process, continued from one of the angles vertically to the long axis of the scute, analogous to the peg or tooth of a tile, and fitting into a depression on the under surface of the opposite angle of the adjoining scute; thus serving to bind together the plates of the imbricated

* "On trouve parmi ces os du Jura une petite dent pointue et un peu tranchante, fort semblable à celle du Crocodile de Caen," *l. c.* ix. p. 283, pl. ccxxxiv. fig. 8, *i. e.* the *Teleosaurus Cadomensis*, the teeth of which are "longues, grêles, arquées, et très-pointues, mais non pas tranchantes." *Ibid.* p. 271. Cuvier then proceeds to say, "Mais il y en a aussi de beaucoup plus grosses et plus obtuses, telles que celle de la fig. 7, qui pourraient annoncer une autre espèce." *Ibid.* p. 283. It is with this other species that the blunt-toothed Crocodilian of the Wealden and Purbeck limestone bears most resemblance.

bony armour, and repeating a structure which is highly characteristic of the large bony and enamelled scales of the extinct ganoid genera of fishes, *Dapedius* and *Tetragonolepis*. Many of the scutes are 6 inches in length and $2\frac{1}{2}$ inches in breadth.

The exterior surface of the scute is impressed, as in the Teleosaur, by numerous deep, round, or angular pits, from two to four lines in diameter, and with intervals of about two lines, formed by convex reticularly disposed ridges of the bone; but a larger proportion of the anterior part of the scute is overlapped by the contiguous scute than in the Teleosaur, and this part is smooth, and thinner than the rest of the scute. The whole of the inner surface of the scute is smooth; but on a close inspection it is seen to be everywhere impressed by fine straight lines, decussating each other at nearly right angles, and indicating the structure of the corium in which the scutes were imbedded. From the size and strength of these dermal bones, their degree of imbrication, and the structure for interlocking, we may conclude that the Swanage Crocodilian was better mailed than even the extinct Teleosaur, which Cuvier regarded as "l'espèce la mieux cuirassée de tout le genre."

If the detached vertebræ from the Wealden, communicated by Dr. Mantell to Cuvier, belonged to the obtuse-toothed species and not to the *Suchosaurus cultridens*, it would then have been known that the Swanage Crocodile deviated, like the Teleosaur and most extinct Crocodilian species of the secondary strata, from the Crocodiles, Alligators, and Gavials of the present day, in having both articular extremities of the body of the vertebra slightly concave.

Cuvier* has associated the obtuse teeth with this form of vertebra without hesitation; but it must be admitted that there was room for some doubt, two distinct species, at least, having been indicated by the fossil teeth.

In the slabs between which the remains of the Swanage Crocodile are divided, the vertebræ were unfortunately all at right angles to their plane, and are fractured across the middle, one extremity being buried in one of the halves of the slab, and the other in the opposite half. By permission of the Trustees of the British Museum, and the kind aid of the distinguished Mineralogist at the head of the Geological Department, this doubt has been solved since the reading of the present Report at Plymouth. The limestone has been carefully removed from the two extremities of the same vertebra, and both are equally but slightly concave.

	In.	Lines.
The length of the body of the vertebra examined was . .	1	10
Vertical diameter of the articular extremity	1	9
Transverse diameter of the articular extremity	1	8
Ditto of middle of the body	0	11
Ditto of entire vertebra, including the transverse processes	10	0
Height of entire vertebra, including spinous process . .	4	4
From the lower part of the centrum to the base of the transverse process	2	6

There is a small irregular medullary cavity in the centre of the body of the vertebra: this cavity is much more capacious in the *Poikilopleuron*: the exterior compact crust of the body of the vertebra is about two lines in thickness. The suture which joins the neural arch to the centrum is conspicuous; it forms an ascending angle or curve at its middle part. The body of the

* "Les vertèbres sont un peu concaves aux deux extremités, ce qui les rapproche du Crocodile de Caen et du deuxième de ceux de Honfleur; cependant je les trouve plus voisines du premier pour l'ensemble. Les dents sont pour la plûpart plus obtuses même que dans nos Crocodiles vulgaires, et ressemblent en ce point à la seconde du Jura que j'ai décrite ci-dessus."—*L. c.*, p. 323.

vertebra expands in a greater degree to form the subconcave articular surfaces than in other biconcave vertebræ of the same length; and both in this character, in its smooth surface, and circular transverse contour at the lower part, the *Goniopholis* resembles the *Streptospondylus* more than it does the *Teleosaurus*.

The medullary canal, at the middle of these vertebræ, presents in transverse section the form of an inverted triangle, the apex sinking into the body of the vertebra. The transverse processes of the lumbar and anterior caudal vertebræ are long, straight, and comparatively slender; those of the sacral vertebræ are relatively thicker, and the spaces inclosed by their expanded extremities are smaller than in either the Teleosaurs or true Crocodiles. The antero-posterior extent of the two sacral vertebræ is three inches two lines.

The ilium is broader than in the existing Crocodilians; the bifurcation of the proximal end of the ischium is more marked, and the iliac branch is more regularly rounded; the pubic branch is longer, more slender, and its articular end is more regularly convex; the distal or lower part of the ischium expands into a relatively broader plate. This character is still more conspicuous in the pubis, which equals the ischium in breadth, and begins to expand much nearer the proximal extremity than in the existing Crocodiles. In these modifications of the pelvis, as well as in the biconcave structure of the vertebra, the Crocodilian of the Purbeck limestone approaches nearer to the characters of the Enaliosaurs; and we may infer that its habits were more decidedly marine than are those of existing Crocodilians. The caudal vertebræ were provided with long, narrow, unanchylosed chevron bones.

The portion of the lower jaw preserved belongs to that part of the left ramus included between the articular extremity, which is broken off, and the commencement of the dental series; it measures one foot six inches in length, and five inches in greatest depth. In these proportions, and the curve of the lower margin, it deviates from the ancient Teleosaurs and Steneosaurs, and resembles the modern Crocodiles; and although not quite equalling these in the robust proportions of the jaws, yet it much exceeds in this respect the Crocodilians with more slender teeth. What the real length and form of the jaws may have been, and how nearly they may have approached the Gavial type, there is not at present means to determine. Sufficient, however, has been pointed out from the remains which are at present discovered, to show that the Swanage Crocodilian differs from the existing subgenera of Crocodilians in a greater degree than these do from one another; that in the form of its vertebræ and the structure of the dermal armour, it is much more nearly allied to the *Teleosauri* and other Crocodilian genera of the biconcave vertebral system; and that, in this ancient and extinct group of Crocodilians, it typifies the Alligator family of the Crocodilians of the ball-and-socket vertebral system.

I propose to name the subgenus indicated by the known remains of the Swanage Crocodile, *Goniopholis*, in reference to the rectangular form, size, number, and firm junction of the osseous scutes (φολίδες), with the specific name of "*crassidens*."

In a collection of fossil Saurian remains from the Hastings beds in the possession of Gilpin Gorst, Esq., F.G.S., is the base of the tooth of the *Goniopholis crassidens*, eight lines in diameter.

Remains of Crocodilians are stated by Dr. Mantell to have been found, though very rarely, in the lower chalk, and in the grey chalk at Dover*.

Teleosaurus.

The family of extinct Crocodilians, which next remains to be noticed, is

* Illustrations of the Geology of Sussex, 4to, 1827, p. 64.

characterized by a combination of a biconcave structure of the vertebræ, with long, narrow jaws, armed with slender, conical, sharp-pointed and equal teeth, adapted, like those of the existing Gavials, for the seizure and destruction of fishes. The species are separated into two genera, according to the difference of position in the external nostril, which, in the one called *Teleosaurus*, is terminal, or at the extremity of the upper jaw; in the other, called *Steneosaurus*, is a little behind and above the termination of the upper jaw. The species of both genera are confined to the oolitic division of the secondary rocks, and, since there were scarcely any Mammalia during that period, whilst the waters were abundantly stored with fishes, it might, *à priori*, have been expected, Dr. Buckland justly observes, "that if any Crocodilian forms had then existed, they would most nearly have resembled the modern Gavial*." The modification in the structure of the vertebral column, and their complete mail of imbricated bony scutes, also indicate that the habits of the ancient *Teleosauri* and *Steneosauri* were more strictly marine than are those of the modern Gavials, and that their powers of swimming, of pursuing and overtaking their aquatic prey, were greater.

The extinct reptile from which the characters of the genus *Teleosaurus* are derived, is one of the earliest of the evidences of ancient Reptilia which is recorded in a scientific publication. A brief description, and figures of an incomplete skeleton found in the lias (alum schale) of the Yorkshire coast, about half a mile from Whitby, were published by Messrs. Wooller and Chapman, in two separate communications, in the 50th volume of the Philosophical Transactions, 1758, (Pt. 2, pl. xxii. and xxx.). Their figures exhibit a contorted and incomplete vertebral column, about nine feet long, and a cranium slightly displaced, two feet nine inches in length. About ten vertebræ of the lumbar and sacral region of the trunk, and twelve vertebræ of the tail remain in place; the cervical, dorsal, and middle coccygeal vertebræ were indicated only by their impressions; and these are fewer in number than the vertebræ in the existing Crocodiles. The skull is reversed, presenting its basal surface to view: the single occipital condyle, the zygomatic arches, terminated behind by the strong tympanic bones, and the large convex articular surface in each of these, for the lower jaw, placed in the same transverse line as the occipital condyle, are all recognizable. The skull appears to contract gradually to a pointed muzzle, but in reality to the base of a long and slender maxillary beak. In the remaining basal or posterior portions of the jaws, the sockets of the teeth are seen separated by intervals of about nine lines; in some of these there are pointed conical teeth, which cross alternately those of the opposite jaw. The teeth are covered with polished enamel†.

Each of the vertebræ is three inches in length. Near the pelvic region, the shaft of the femur, including the head, was exposed, measuring between three and four inches in length. A few fragments of ribs were found near the dorsal vertebræ. The authors of the papers just analysed perceived sufficient resemblance between their fossil and the skeleton of the Crocodile to refer it to that family of reptiles‡; but their figures and descriptions gave rise to various opinions respecting the affinities of the Whitby fossil in the writings

* Bridgewater Treatise, vol. i. p. 250.

† Cuvier truly states, "Elles n'ont pas été décrites particulièrement, et il est impossible de juger de leurs caractères par la gravure."—Oss. Foss. 1836, ix. 225.

‡ Captain Chapman says, "It seems to have been an alligator;" (*l. c.*, p. 691.) and Mr. Wooller thinks that "it resembles in every respect the Gangetic Gavial." It will be shown, however, that the fossil really differs more from the Gavial than the Gavial does from any other existing Crocodilian.

of subsequent naturalists and anatomists. Camper, for example, pronounced it to be a whale, perhaps meaning a dolphin, for, as Cuvier remarks, the presence of teeth in both jaws at once proves the fossil not to belong to the Balænæ, which have no teeth, nor to the Physeters, which have (conspicuous) teeth only in the lower jaw. Faujas adopted Camper's opinion, referring the fossil to the genus *Physeter*, and adding some reasons which are contradicted by the descriptions given by both Chapman and Wooller. Cuvier, in the first edition of his 'Ossemens Fossiles,' after refuting the opinion of Faujas, says, "La vérité, ainsi que nous le verrons, est que c'étoit réellement un crocodile." The subsequent analysis, to which Cuvier here refers, led him in 1812 to the conclusion that it belonged to the genus of Crocodiles, and was most probably identical in species with the Crocodile of Honfleur.

In 1836, however, when so many new and singular genera, allied to the Crocodilian family, had been added to the catalogues of Palæontology, chiefly by the labours and discoveries of English anatomists and geologists, Cuvier expresses his opinion on the fossil described by Wooller and Chapman with more caution. He says, "Il reste maintenant à savoir si c'est un crocodile, ou l'un de ces nouveaux genres découverts dans les mêmes bancs. Les os des extremités y sont trop incomplets, et la tête n'y est pas représenté avec assez de détails pour décider la question ; mais les vertèbres me paraissent plus longues, rélativement à leur diamètre, que dans les nouveaux genres, et plus semblables par ce caractère à celles des Crocodiles. Ceux qui retrouveront l'original, s'il existe encore, pourront seuls nous apprendre si les autres caractères répondent à celui-la."

I have made inquiry at the British Museum, to which the collections formerly belonging to the Royal Society were transferred, but no specimen corresponding with the account and figures given by the Whitby naturalists exists in that collection.

A second specimen of a long and slender-nosed Crocodilian, was obtained from the lias near Whitby, between Staiths and Runswick, in the year 1791*; and a more perfect skeleton was discovered in the alum shale of the lias formation at Saltwick, near Whitby, in 1824. Both these specimens so closely resemble the older fossil in all the points in which a comparison can be established, as to dissipate the remaining doubts as to the nature and affinities of the specimen from the same locality, described in the Philosophical Transactions for 1758. The skeleton, discovered in 1824, is figured in Young and Bird's 'Geological Survey of the Yorkshire Coast', 2nd edit. 1828, pl. xvi. fig. 1. p. 287, and in Dr. Buckland's 'Bridgewater Treatise,' vol. ii. pl. xxv. It is now preserved in the museum at Whitby, where I have closely examined it. In this specimen are preserved the cranium, wanting the snout, the whole vertebral column, the ribs, and the principal parts of the four extremities, together with the dorsal, and part of the ventral series of dermal bones. The entire length of the skeleton, following the curvature of the spine, is fifteen feet six inches, to which may be added two feet six inches for the lost snout. The cranium posteriorly is broad, depressed, and square-shaped: it begins to contract anterior to the orbits, and gradually assumes the form of the narrow depressed snout; the converging sides of the maxillæ are concave outwardly. The zygomatic spaces are quadrilateral, longer in the axis of the skull than transversely; the orbits are subcircular; they look upwards and slightly outwards; their margins are not raised, and their interspace is slightly concave. The parietal bone is relatively longer than in the Gavial, and sends up a longitudinal median crest, from the posterior part of which

* See History of Whitby, vol. ii. pp. 779, 780.

a strong process extends on each side outwards, and curves slightly backwards parallel with the ex-occipitals, to join the mastoid and tympanic bones, the latter of which expands as it descends to form the joint for the lower jaw.

	Feet.	In.	Lines.
Breadth of posterior part of skull	1	0	0
Length of parietal crest	0	6	0
Breadth of the interorbital space	0	3	2
Antero-posterior diameter of the middle of tympanic pedicle	0	2	5
Vertical diameter of orbit	0	2	0
Antero-posterior of orbit	0	3	0
From lower margin of orbit to alveolar border	0	1	3

From these dimensions it may be calculated that the entire length of the skull must have exceeded 4 feet 6 inches.

The skull of one of the Caen *Teleosauri* measures 3 feet 4 inches, whence Cuvier calculates the entire length of the animal at near 15 feet. The Whitby Teleosaur agrees with the Caen species, and differs from the Gavial in the following particulars: the anterior frontal is less extended upon the cheek; the lachrymal is much more extended, and is larger at its base; the jugal bone is more slender. The posterior frontal, which separates the temporal from the orbital cavities, is much longer and narrower. The parietal and occipital crests each form a thin trenchant plate, and are not flattened above. The mastoidean angle is not uninterruptedly united with the back part of the articular process of the tympanic, it is separated from it by a large depression, which is overarched by a trenchant crest belonging to the ex-occipital. The mastoidean bone has a concavity at its descending part, of which there is no trace in the Gavial. The indentation between the articular process of the tympanic, and the tuberosity of the basi-occipital is much smaller than in the Gavial, and the basilar tuberosity projects downwards in a less degree. The pterygoid ala is not expanded externally, as in all Crocodiles, but is contracted by a large fissure, at the part where it goes to unite itself to the bone; the orbital margin of the malar is not raised, and does not leave behind it a deep fissure as in the Gavial. The malar does not rise to join the posterior frontal bone; but, on the contrary, the frontal descends to join the malar at the external margin of the orbit. The vacuity between the orbit and the anterior part of the tympanum is much elongated in the fossil, and occupies four-fifths of the temporal fossa; the anterior part of this fossa is narrow and acute. The columella or ossicle of the ear is cylindrical, and much larger in proportion than in any known Crocodile or other reptile.

Cuvier calculates the number of teeth in the *Teleosaurus Cadomensis* to be 180, viz. $\frac{45-45}{45-45}$.

The *Teleosaurus Chapmanni* has at least 140 teeth.

The Gavial has 112, or $\frac{28-28}{28-28}$.

The teeth of the Whitby Teleosaur are as slender and sharp-pointed, but not so compressed, as in the Gavial; they correspond with those of the Caen Teleosaur, and equally illustrate the dental characters usually attributed to the present extinct genus*.

The Whitby Teleosaur differs from the Caen Teleosaur, as does the

* M. H. v. Meyer refers to the genus *Teleosaurus* (Palæologica, p. 115) the thick obtuse teeth of the Wealden or Sussex Crocodile figured by Dr. Mantell in his 'Illustrations of the Geology of Sussex,' at pl. v. figs. 1, 2, 7, 9, 10, and 12. These teeth, however, belong to *Goniopholis*, as does also the scute figured in pl. vi. fig. 8; and they are accompanied with deviations from the characters of *Teleosaurus* in the skeleton as striking as those which are manifested in their own robust and obtuse figure.

Monheim Teleosaur*, in having the upper temporal fossæ longer in proportion to their breadth; but it differs from the Teleosaurs of both Caen and Monheim in the more equal size of the teeth, and from the Monheim species in the greater number of teeth, the *Teleosaurus priscus* having at most $\frac{27-27}{26-26} = 106$. The median frontal in the Whitby Teleosaur is slightly concave: in the Caen species it is flat. The basi-occipital is perforated by the common terminal canal of the Eustachian tube close to the junction with the sphenoid, and, on each side of the hole, it expands into a rough tuberosity. The body of the sphenoid is compressed, characterized by two processes or narrow ridges, continued one from each side of the middle of the sphenoid obliquely backwards. The pterygoid bones are relatively smaller than in the Gavial. The palatine bones are more extended posteriorly, and articulate with the transverse bones. The posterior apertures of the nasal canals are placed more forwards upon the base of the skull than in existing Crocodiles.

Vertebral Column.—The number of vertebræ in the true Crocodiles of the present period rarely exceeds sixty, which is the number originally assigned by Ælian† to the spinal column of the Crocodile of the Nile. Cuvier generally found 7 cervical, 12 dorsal, 5 lumbar, 2 sacral, and 34 caudal vertebræ.

In the *Crocodilus acutus* a thirteenth pair of ribs is occasionally developed, and, according to Plumier, it has two additional caudal vertebræ.

The Alligator (*Alligator Lucius*) has sixty-eight vertebræ, the additional ones being in the caudal region.

The Gavial has sixty-seven vertebræ, disposed as follows:—7 cervical, 13 dorsal, 4 lumbar, 2 sacral, and 41 caudal vertebræ.

The very perfect specimen in the Whitby Museum displays the number of the vertebræ through the whole spinal column, and establishes another difference between the Teleosaur and the Gavial, the former having a number of vertebræ intermediate between the Crocodiles and Gavials, viz. 64, with a special peculiarity in the excess of costal vertebræ, as the following formula indicates, viz. 7 cervical, 16 dorsal, 3 lumbar, 2 sacral, 36 caudal.

In all sub-genera of existing Crocodiles, as in the extinct tertiary species, the hind surface of the vertebra is convex, the fore surface concave, except in the atlas and the two sacral vertebræ.

Cuvier, who had the opportunity of seeing only the annular part (neurapophyses) of the cervical vertebræ of the Caen Teleosaur, regrets his inability to state whether either of the articular extremities of the centrum were convex, or which of them‡. The Whitby Teleosaur decides this question, and shows that both articular extremities of the vertebræ are slightly concave in the cervical as in the rest of the vertebral series.

The atlas in the Teleosaur corresponds essentially with that of the Crocodiles, as is shown by the three main component parts of this bone, from a Whitby Teleosaur in Lord Enniskillen's collection. The body or centrum is a transverse quadrilateral piece, smooth and convex below, narrowing like an inverted wedge above, with six articular facets, viz. a concavity in front for the occipital condyle, a flat rougher surface on each side of the upper part for the attachment of the neurapophyses; a posterior facet for the anterior part of the detached odontoid element of the axis; and the small surface on each lateral, posterior and inferior angle for the atlantal ribs. The neurapophyses are pyramidal processes, with their apices curved towards each other; they are relatively smaller in proportion to the centrum than in the Crocodiles.

* *Crocodilus priscus*, Soemmerring.

† De Naturâ Animalium, lib. x. sect. xxi, Jacob's Ed., 8vo, vol. i. p. 228.

‡ Ossem. Fossiles, 4to, 1824, tom. v. pt. ii. p. 137.

The general anterior concavity for the reception of the occipital tubercle is formed at its circumference by the centrum and neurapophyses of the atlas, and at its middle by the anterior detached odontoid epiphysis of the axis, which is here evidently the analogue of the so-called atlas in the *Ichthyosaurus*, the true body of the atlas in the Teleosaur representing the first inverted wedge-shaped bone in the Ichthyosaur. The spine of the atlas is a large strong oblong piece, articulated with the neurapophyses of the atlas, and partly overlapping those of the axis.

The cervical vertebræ have strong transverse processes developed one from each side of the centrum, and one from the base of each neurapophysis. The posterior articular processes look obliquely downwards and outwards, the anterior ones obliquely upwards and inwards. The spinous process is compressed, its base coequal with the whole antero-posterior extent of the neurapophysis; its height equal to the distance from its base to the upper transverse process; it inclines slightly backwards, and is slightly rounded off at the summit. The cervical rib is bifurcate at its vertebral end, the tubercle being as long as the head and neck; its distal end is expanded into the hatchet shape, the posterior angle being most produced, and overlapping the costal process of the next vertebra behind. The same mechanism for fixing and strengthening the neck thus existed for the advantage of the ancient marine Crocodiles, as we find in those of the existing epoch.

In the dorsal region the ribs exchange the hatchet for the ordinary lengthened form, and soon begin to lose the head and neck, as in existing Crocodiles; after the fifth they no longer articulate with the central element, but only to the transverse process of the neurapophysis, which increases in antero-posterior extent and thickness, and presents an oblique notch at its anterior angle, for the reception of the tubercle, now the only head of the rib. The number of the dorsal ribs exceeds that of any existing Crocodilian, being, as above indicated, 16 pairs. The spinous process is proportionally strong; in the Whitby specimen it measures in most of the dorsal vertebræ 2 inches in antero-posterior extent, and seven lines in transverse diameter or thickness: the height of these spines seems not to have much exceeded that of the cervical spines, but they are more truncated at the summit.

A posterior dorsal or lumbar vertebra of a Teleosaur from the Whitby lias, in the collection of Mr. Ripley, corresponds with the vertebral characters of *Teleosaurus* in the slight concavity and circular contour of the terminal articular surfaces of the body, and in the great antero-posterior extent of the spinous processes; but that of the transverse process does not exceed one-half the length of the body of the vertebra, which is 2 inches 6 lines. The transverse process is supported by two short obtuse slightly-developed ridges, which rise from the upper part of the side of the body, as far apart as to include one-third of the length of the body between them, and converge to the under part of the transverse process; a similar ridge extends from the upper part of the posterior end of the transverse process obliquely backwards to the base of the posterior articular process. The neural arch is anchylosed to the centrum in this vertebra. The supporting buttresses of the transverse processes are not described by Cuvier in the dorsal vertebræ of the Caen Teleosaur; nor have I met with any dorsal or lumbar vertebræ of the Whitby species, except the present, that was sufficiently perfect to exhibit this character; it may, however, be constant and characteristic of the genus. It faintly indicates one of the most striking characters of the vertebræ of the *Streptospondylus*. The anterior and posterior margins of the spinous process are slightly excavated, and thus retain a character which is transitory in the Crocodile, and peculiar to an early period of its existence.

The transverse processes of the two sacral vertebræ are thick, strong and expanded at their extremities.

The bodies of all the vertebræ are compressed laterally, and concave antero-posteriorly at the sides; but this character is more strongly marked in the anterior caudal vertebræ, which are flattened along the inferior surface; these vertebræ in the Whitby specimen were 2 inches 8 lines in length. The transverse processes are longer, but narrower antero-posteriorly than in the lumbar or dorsal vertebræ. The hæmapophyses are united at their peripheral end, forming chevron bones, but are detached at their central ends, which are articulated, as in recent Crocodiles, with the interspaces of the vertebral centres. The caudal vertebræ progressively diminish in every diameter, save length, from the middle to near the end of the tail; the terminal vertebræ are shorter than the rest.

The sternum and sternal ribs closely agree with the ordinary Crocodilian type. I have not yet seen a specimen of the abdominal sternal ribs.

Pectoral extremities.—The scapula and coracoid resemble, in general form, those of the Crocodile, but are relatively smaller, in correspondence with the smaller size of the anterior extremities. The *scapula*, for example, is only one-third the length of the femur; it is straighter than that of the Crocodile; both margins are nearly equally concave, instead of the anterior one being convex: the humeral end is less expanded, and is more obliquely truncated. The *coracoid* is longer than the scapula, instead of being, as in the Crocodiles, shorter: this probably depends upon the breadth of the fore part of the body, which regulates the extent of the coracoid, while the proportions of the scapula more exclusively depend upon the development of the pectoral extremity. The coracoid of the Teleosaur differs also from that of the Crocodile in the greater expansion of its humeral end, the more transverse position of its sternal convex extremity, and a nearer approach to parallelism in the direction of the two lateral margins.

In the Whitby Teleosaur, discovered in 1824, the humerus of the right anterior extremity, and the humerus and bones of the fore-arm of the left are preserved nearly in their proper relative positions. The humerus is shorter in proportion than in the Crocodiles, its length scarcely exceeds the antero-posterior diameter of two of the cervical vertebræ. The antibrachial bones are still more curtailed in their proportions; the longest bone, or ulna, being not quite half the length of the humerus.

No portions of the carpal or other bones of the paddle are preserved, but the presence of the antibrachial bones, distinct from each other, and of the ordinary form and breadth at the distal end, forbid our supposing them to have been naturally deficient or of abortive proportions in the *Teleosaurus*. The humerus, radius and ulna must have existed for a purpose, and that purpose, we may conclude, from the modifications for an aquatic life in the rest of the skeleton, to have been the support and movement of a palmated manus; an organ which would be of great use in turning and regulating the course of the swimmer, and in bringing the long and slender snout, with the terminal nostrils, to the surface. The fore-paddles were doubtless much smaller than in ordinary Crocodiles, and this difference of proportion related both to the less frequent resorting of the Teleosaur to dry land, and to the light and slender character of its jaws and teeth, and the consequent diminution of the weight of its head.

Pelvic extremity.—The pelvis of the Teleosaur was attached, as in the Crocodile, to the thickened and expanded transverse processes of two sacral vertebræ. These processes are stronger in the vertical direction, and intercept a relatively smaller and more regularly elliptical space than in the exist-

ing Crocodiles; the anterior one appears not to have been so much expanded in the antero-posterior direction. The iliac bone seems to have been shorter in the antero-posterior diameter, but longer, as measured transversely to the axis of the trunk, and thus to have made a slight approach to its characteristic form in the Enaliosaurs.

Both the ischium and pubis are relatively more expanded than in the Gavial. The pelvic extremities are preserved in the Whitby specimen in nearly their true relative positions; but the right is thrown directly over the left. The femur presents the usual Crocodilian form, but is relatively more slender than in the existing Crocodilians; it is slightly twisted, and bent in two directions. Its proximal end is expanded, compressed with a regular convex curve, describing a semicircle; the trochanter is represented by a ridge which gradually subsides, and is lost upon the surface of the shaft. This is nearly cylindrical at the upper part, but is produced at the anterior or convex side along the distal half in the form of an obtuse ridge. The condyles are very feebly indicated. In the Whitby specimen of 1824,

	Feet.	In.	Lines.
The length of the femur is	1	3	3
The breadth of proximal end of ditto . .	0	2	10
The diameter of middle of shaft	0	1	4

Both the tibia and fibula are subcompressed towards their distal end: the length of each bone is 8 inches. The shaft of the fibula is nearly as thick as that of the tibia. The bones of the leg of the *Teleosaurus* resemble those of the Aëlodon in their relative shortness as compared with the femur. In these, and probably in other ancient Crocodiles with biconcave vertebræ and marine habits, the tibia is little more than half the length of the femur; while in recent Gavials it is two-thirds that length. There are five tarsal bones, two in the proximal and three in the distal row, as in the Gavial; but they are of more equal size; the two proximal bones being by no means so disproportionately large. All the long bones have distinct medullary cavities, and these are even present in the metatarsals. In the Whitby specimen,

The length of the middle metatarsal is	6 inches.
The breadth of its proximal end	10 lines.
The breadth of its distal end	6 lines.

The ungual phalanges are depressed, smooth and convex above, rounded at the end.

Dermal armour.—The bony dermal scutes of the Teleosaur were regularly disposed like those of existing Crocodiles, in both longitudinal and transverse series; the posterior margin of one scute covered the base of the succeeding scute*, and they slightly overlapped each other laterally.

Cuvier states that one of the fossils of the *Teleosaurus Cadomensis* presents all those of one side in their natural situation, exhibiting, in the part of the body included between the first dorsal and the beginning of the tail, fifteen or sixteen transverse rows, containing five scutes on each side; so that there were at least ten longitudinal rows of these dermal bones.

The scutes are arranged in the same manner and number, at least as regards the transverse rows, in the Whitby Teleosaur; these rows being indicated by the large dorsal scutes still occupying their natural position in an uninterrupted line along the back; they are twenty in number, and sixteen cover the vertebræ included between the last cervical and first caudal.

The scutes of the *Teleosaurus Chapmanni* differ as much from those of the existing Gavials and Crocodiles, as do those of the *Teleosaurus Cadomensis*,

* Cuv., *l. c.* p. 279.

being thicker, rectangular, and having the outer surface impressed with circular pits or indentations from three to four lines in diameter, which are not confluent, but separated.

The median dorsal scutes of the Whitby specimen are nearly square, having the longer diameter, about three inches and a half across, placed transverse to the axis of the body, and with the outer margin slightly rounded. Each of these scutes is traversed, as in the *Teleosaurus priscus*, by a longitudinal ridge, which is less developed than in the Gavials. The median dorsal scutes of the *Teleosauri Cadomensis* and *priscus* appear to differ from those of the *Teleosaurus Chapmanni* in being more oblong transversely, and with the posterior and lateral margins rounded off. Cuvier does not allude to the carinated character of these plates in the Caen species.

The lateral and ventral scutes of the *Teleosaurus Chapmanni* are more perfect squares than those next the spine, but differ less in form and size from them, than in the Caen Teleosaur. They are marked externally by the same impressed pattern, but are not carinated. The median abdominal scutes are not opposite but alternate; their median margins are rounded off, or slightly angular; and, while the anterior part of that margin is overlapped by the posterior half of the opposite scute, in advance, the posterior half overlaps the succeeding scutum of the opposite side. The verticillate cuirass of these ancient Crocodiles is thus securely braced round the trunk by this interlocking of the inferior extremities of each ring of scutes, whilst the imbricated arrangement would allow of a certain sliding motion of the rings upon each other sufficient for the expansion of the chest in breathing. The scutes in the fine specimen in the Whitby Museum measure about five lines in thickness, but are thinned off at the edge.

Having now detailed the anatomical particulars which a study of the magnificent and unique skeleton of the *Teleosaurus*, in the museum at Whitby, has enabled me to add to the previous descriptions, by Cuvier and other anatomists, of the osteological structure of this extinct Crocodilian genus, I next proceed to notice the principal examples of the same genus which are preserved in other collections of British Fossil Reptiles.

The first of these is a fine skull of the same species of *Teleosaurus*, and from the same lias beds near Whitby, in the museum of Mr. Ripley of that town:—

	Feet.	Inches.
The length of the entire skull is	2	9
From the angle to the beginning of the long symphysis of the lower jaw	1	3
Breadth of the lower jaw at the posterior commencement of symphysis	0	$2\frac{1}{2}$
Breadth of the extremity of the lower jaw	0	1

The extremity of the upper jaw well exhibits in this specimen the characteristic generic modification of its infundibuliform expansion, supporting the terminal nostrils, and resembling the extremity of the elephant's proboscis, wanting the digital process.

This cranium also clearly exhibits the specific characters by which the *Teleosaurus Chapmanni* of the Yorkshire lias differs from the *Teleosaurus Cadomensis* of the Caen oolite, viz. the greater antero-posterior extent of the upper temporal openings as compared with their transverse diameter in the *Teleosaurus Chapmanni*; the similar but slighter difference in the form of the orbits, the greater breadth of the interorbital space, which slightly exceeds the transverse diameter of the orbit instead of falling short of that diameter, as in the *Teleosaurus Cadomensis*.

A cranium of the *Teleosaurus Chapmanni*, in the museum of the Philosophical Institution at York, and another in the museum at Scarborough, offer the same specific characters as the Whitby specimens. In the Scarborough cranium the diameter of the orbit is 2 inches 3 lines, while that of the interorbital space is 2 inches 6 lines.

In the museum of the Natural History Society at Lancaster there is a chain of five dorsal vertebræ of the *Teleosaurus Chapmanni*, from the Whitby lias, measuring 1 foot in length ; each vertebra is 2 inches 4 lines in length. A section of these vertebræ showed a small cavity in the centre of the cancellous structure of the body*.

Teleosaurus Cadomensis.—Specimens of fragments of the jaw, teeth and vertebræ of this species have been discovered in the Bath oolite at Enslow, near Woodstock, and in the oolite at Stonesfield.

Teleosaurus Cadomensis (var.).—Of this species, which is nearly allied to, if not identical with *Cadomensis*, I have examined a posterior cervical vertebra from the oolite near Chipping Norton, now in the collection of Mr. Kingdon of that town. The sides of the centrum are less compressed than in the *Teleosaurus Chapmanni*, and the articular extremities have a more circular contour, the transverse exceeding the vertical diameter. There is no appearance of a ridge along the under surface : the transverse process of the centrum arises close to the neurapophysis.

	Inch.	Lines.
The length of this vertebra is	1	5
Transverse diameter of centrum	1	3
Vertical diameter of centrum	1	$1\frac{1}{2}$

Teleosaurus asthenodeirus, Nob.—If the cranium of this Saurian should correspond with the characters of the genus *Teleosaurus* which are exhibited by the vertebræ and scutes here described, a distinct species of this genus is very evidently indicated by them, characterized by the smaller size of the cervical ribs, and the consequently weaker structure of the neck.

In the Oxford Museum are preserved two cervical vertebræ and a dermal bone of this species, from the Kimmeridge clay at Shotover. The articular extremities and general form of the body of the vertebræ accord with the Teleosaurian type.

	Inches.	Lines.
The length of the centrum is.....	2	2
Vertical diameter of articular end	1	6
Transverse diameter of articular end.....	1	5
Antero-posterior extent of lower transverse process	0	6

This process arises near the lower surface of the centrum, about half an inch from the anterior extremity of the bone. It is separated about the same distance from the upper transverse process, which is continued from the base of the neurapophysis ; both the supports of the cervical rib are one-third smaller than the corresponding processes in the *Teleosauri Chapmanni* and *Cadomensis*, and are less extended from the sides of the vertebra.

The dermal scute is devoid of a ridge ; one-half of the external surface is pitted with well-defined hemispherical depressions, separated from each other by about half their breadth, the smallest being nearest the margin ; the other half of the scute is smooth, and indicates that it was overlapped by the ad-

* I have much pleasure in expressing my thanks to S. Simpson, Esq., the Secretary of this excellent Institution, for the prompt acquiescence with my desire to have a section of these vertebræ made ; and likewise to Thos. Satterthwaite, Esq., a member of the Society, for an accurate drawing of the fossil.

joining scute, according to the characteristic disposition of this fish-like covering of the present extinct marine genus of Crocodilians.

In the Hunterian Collection are two entire dorsal vertebræ, with part of a third, fractured through the middle of the body, and displaying a small cancellated cavity filled with calcareous spar, as in the *Teleosaurus Chapmanni*. These vertebræ present the slightly concave articular extremities, and the other characters of the genus *Teleosaurus*. The length of the centrum, measured along the under surface, is 2 inches 6 lines; vertical diameter of articular end 2 inches; transverse diameter 1 inch 10 lines; transverse diameter of the middle of the body 1 inch. Both the inferior and lateral surfaces of the body are regularly concave, lengthwise; and smooth, except near the expanded articular extremities, where they are striated in the axis of the vertebra.

The antero-posterior extent of the transverse process is 1 inch 6 lines; that of the base of the spinous process 1 inch 9 lines. The transverse diameter of the spinal canal 7 lines; its vertical diameter 4½ lines.

These vertebræ are cemented together by a matrix, which closely resembles the gray Kimmeridge clay: and a portion of a species of *Pecten* is attached, which is one of the characteristic fossils of the oolite group of secondary rocks, especially the Oxford clay.

Steneosaurus.

2de Gavial d'Honfleur, Cuv.

Steneosaurus rostro-minor, Geoffroy.

The generic name *Steneosaurus*, proposed by Geoffroy St. Hilaire for the Gavial-like Crocodilians with subterminal nostrils, but applied by him to species with vertebræ of two distinct systems, and altogether rejected by M. Hermann von Meyer, I propose to retain for that section of the Geoffroyan genus, including the species with vertebræ subconcave at both extremities, as in the genus *Teleosaurus*.

Remains of the genus *Steneosaurus*, thus defined, occur in the Kimmeridge clay at Shotover, and in the great or middle oolite.

I shall first describe a mutilated cranium from Shotover, preserved in the museum of Professor Buckland at Oxford. In this specimen the sides of the inter-temporal crest slope away, except at its anterior part, where it expands to one inch in breadth, and is convex: its longitudinal contour is slightly convex. The posterior boundary of the temporal fossa sinks below the level of the upper part of the cranium, and likewise terminates above in a sharp ridge, as in *Teleosaurus*. The ex-occipitals send out a transverse ridge, increasing in size to the mastoid process, below which there is a foramen: the cranial canal is cylindrical. The ex-occipitals so completely surround the posterior aperture of the cranium, that when the basi-occipital is displaced it remains entire. This is not the case in the *Teleosaurus*.

	Steneosaurus.		*Teleosaurus Chapmanni.*	
	Inches.	Lines.	Inches.	Lines.
Breadth of posterior part of cranium	11	0	5	6
From lower margin of condyle to inter-temporal ridge	4	8	2	4
Length of temporal fossa	5	0	2	6
Breadth of temporal fossa	5	0	2	0

In the upper jaw the teeth are closer together and relatively larger: there are 3 teeth in front of, and 27 behind, a short diastema: there is no groove along the inner side of the ramus of the jaw. In the lower jaw the post-articular

angle is equal in length to the transverse diameter of the articular surface, approaching thus to Plesiosaurian proportions, whilst it is longer in the Gavial and in *Teleosaurus*. The articular surface is convex in the middle and concave on each side, as in the *Teleosaurus*, and not regularly concave, as in Gavial: the articular piece is continued more forwards, and is stronger upon the internal side of the ramus. The depth of the ramus at the coronoid ridge is greater, and the coronoid ridge itself is higher: there is no interspace between the angular and surangular elements*. From the angle to the beginning of the symphysis of the jaw is 1 foot 9 inches, the depth of the jaw at the coronoid process is 4 inches. The nostrils are bounded by short intermaxillaries, each of which contains three teeth. Both intermaxillary and maxillary teeth are larger in proportion than in *Teleosaurus*. The maxillary teeth are arranged closer together as they are placed further back. In a fragment of jaw containing three teeth, these are placed obliquely in sockets, from two to three lines apart. The fang is covered by a smooth white cement; the crown with a black enamel, traversed by fine longitudinal, close-set, interrupted ridges, one on each side of the tooth, is stronger than the rest, and meeting, in the unworn teeth, upon an obtuse summit.

In a fragment of a lower jaw of apparently the same species of *Steneosaurus*, in the Hunterian Collection, which includes 6 inches of the posterior commencement of the symphysis, the transverse diameter, at the junction of the rami, is 4 inches 3 lines: the middle of the posterior surface of the junction is excavated by a deep transversely elliptical depression. Both the upper and lower surfaces of this portion of jaw are flat, and the sides are nearly flat, and on right angles with the horizontal surfaces; the intervening angles being rounded off. The inner border of the alveolar tract is higher than the outer. The inferior flattened surface is impressed with some small, irregular, longitudinal vascular grooves, but not with pits or foramina. Eight teeth are contained in an extent of the alveolar tract measuring $5\frac{1}{2}$ inches. The diameter of the circular base of the crown of the tooth is from four to five lines. The matrix appears to be oolite; the cavities in the crowns of the teeth are filled with white spar.

Perhaps the most interesting fact which has resulted from an examination of the British fossils of the present genus is the size and form of the brain, as exhibited by an internal cast of the cranial cavity.

In the museum of Professor Sedgwick there is a slab, in which the head of a *Steneosaurus* is imbedded, the upper part being exposed, from which a considerable part of the bony substance has been broken away, and, amongst the rest, the whole upper wall of the cranial cavity, exposing a tolerably perfect cast of its interior, which represents the brain of the extinct reptile. This cast resembles the smooth convex cerebral lobes of the Crocodile, and a portion of the large optic lobes which lie posterior to them. The cerebrum is $1\frac{1}{2}$ inch in breadth, and the whole of the brain represented by this cast is 2 inches in length. The breadth of this head is $6\frac{1}{2}$ inches. The temporal openings form wide ellipses, 2 inches 9 lines in the long diameter: from the back of the cranium to the commencement of the narrow elongated jaws is 8 inches; from these proportions the length of the individual may be calculated at about 18 feet.

* In the thin, long and slender jaws ascribed to the *Poikilopleuron* by M. Deslongchamps, the coronoid is not raised, and there is an oblong vacuity between the angular and surangular.

POIKILOPLEURON BUCKLANDI, Eudes-Deslongchamps.

Nos. $\frac{294}{2294}$ and $\frac{295}{2295}$, in the Mantellian Collection, are the two moieties of a fossil caudal vertebra, fractured obliquely across the middle of the body, the length of which is to the breadth of its articular extremity as 3 to 2; both extremities are slightly concave; the body is gradually contracted from the two extremities towards the middle part; bears a transverse process developed from the posterior and upper part of its side, behind which there is a shallow groove; has the neural arch anchylosed, without trace of suture, to nearly the whole of the longitudinal extent of its upper surface. The neural arch is provided with anterior and posterior oblique processes, and a broad and thin spine developed at its posterior part, and strongly inclined backwards at its origin; lastly, the vertebra has a large medullary cavity in the centre of the body, filled, in the fossil, with spar. In all these particulars the Palæontologist acquainted with the excellent description by M. Eudes-Deslongchamps of the *Poikilopleuron Bucklandi*, from the oolite at Caen, will not fail to recognise the distinctive characters of that species in the present fossil. It is attached to a mass of the common Wealden stone, which is quarried at Tilgate, and was associated with the bones of the *Iguanodon*.

The length of the present vertebra is 3 inches 9 lines, or $9\frac{1}{2}$ centimeters; that of the caudal vertebræ of the *Poikilopleuron* of Caen is about a decimeter*. We may conclude, therefore, that the individual from the Caen oolite and that from the Wealden were of the same size, and, from this correspondence, it is most likely that the size—25 French feet, which M. Deslongchamps assigns to the entire animal—is the common size of the species.

The vertical diameter of the articular end of the body of the Wealden vertebra is 2 inches 3 lines ($5\frac{3}{4}$ centimeters); the transverse diameter of the same part is 2 inches 2 lines ($5\frac{1}{2}$ centimeters); the transverse diameter of the middle contracted part of the body is 1 inch 4 lines ($3\frac{1}{2}$ centimeters). The external free surface of the vertebra is almost smooth, being faintly marked by fine striæ. The form of the terminal surfaces of the centrum is a full ellipse, with its long diameter vertical. The longitudinal sulcus at the upper part of the side of the body is shallow, and slightly bent, with the convexity downwards; the base of the transverse process is continued from the upper boundary of the groove, and extends along the posterior half of the upper and lateral part of the centrum, and upon the base of the neural arch, which is here wider than the centrum: the transverse process is broken off near its origin. The base of the neurapophysis or side of the neural arch leaves only a very small portion of the upper part of the centrum free at its anterior and posterior part, to form the hole for the transmission of the spinal nerve: the distinction between the present genus and the *Cetiosaurus* is well marked in this respect. The neurapophyses have a less vertical extent than in the corresponding vertebræ of the *Cetiosaurus*, or even than in the Crocodile. From the upper part of the centrum to the upper edge of the anterior oblique process in a vertical line is only 1 inch, or about $2\frac{1}{2}$ centimeters. The base of the spinous process is not thickest at its posterior margin, but gradually expands transversely as it extends forwards, and then, at a distance of 10 lines from its posterior part, it quickly contracts to a very thin plate, which is continued forwards to the conical depression at the interspace of the origin of the anterior oblique processes. The upper part of the spine is broken away, but the remaining base has the same backward inclination as in the Caen *Poikilopleuron*.

From the size and position of the transverse process, the Tilgate vertebra

* "Nos vertebrès ont chacune environ un décimètre de long."—Deslongchamps, *l. c.*, p. 53.

corresponds with the second or third of the first series of caudal vertebræ of the Caen *Poikilopleuron* figured by M. Deslongchamps. There is one character in the Wealden vertebra which is not mentioned in M. Deslongchamps' description of the Caen species, viz. a longitudinal sulcus at the middle of the under surface of the body of the vertebra, at least at its anterior half: the sulcus is not deep, and is 1 centimeter or 4 lines in breadth. The extremity of the under surface seems to be obliquely leveled off to form a single hæmapophysial surface. From this structure it might have been inferred that the hæmapophyses, which by their union form the chevron bone, were closely approximated, if not confluent at their bases, as in the *Iguanodon*; the Caen specimen, in which many of the chevron bones are preserved, proves this to have been the case. The fortunate fracture which demonstrates the peculiarly large medullary cavity in the centre of the vertebral body, gives the best proof that could be required of the generic identity of the Wealden vertebra with the Caen *Poikilopleuron*; and the absence of that cavity in the vertebræ of the *Megalosaurus*, which I have determined by a section of one of the caudal vertebræ, establishes the distinction between that genus and the *Poikilopleuron*.

In the form of its sub-biconcave vertebræ, and the simplicity of their neural arch as compared with the *Streptospondylus* and the *Dinosaurians*, the *Poikilopleuron* manifests its closer affinity to the Cœlospondylian Crocodiles. It agrees with the *Teleosaurus* in the comparative shortness of the fore legs; the mode of articulation of the vertebral ribs appears to be the same, and there is no evidence that it differs in the structure of the abdominal ribs.

The number of caudal vertebræ would appear to be greater; but I know not in what material respect the *Poikilopleuron* resembles the Lizard tribe more closely than does the *Teleosaurus*, unless it should be proved to have five toes on the hind foot, and to want the dermal armour. Subsequent discoveries may prove it to belong, like the *Megalosaurus*, to the *Dinosaurian* order; but as the *Poikilopleuron* is at present known, it seems to have most claim to be received into the *Cœlospondylian* family of the *Crocodilian* order, and perhaps has the closest affinity in that family to the *Crocodilus Bollensis*, Jaeger (*Macrospondylus*, H. v. Meyer).

To the genus *Poikilopleuron* it is most probable that the specimen No. $\frac{141}{2141}$ in the Mantellian Collection belongs, as it agrees in size, in texture, and especially in the character of the external surface with the caudal vertebra last described. As it consists of the annular part or neural arch only, the test of the medullary cavity of the body cannot be applied. It belongs to one of the anterior dorsal vertebræ, and is distinguished by well-marked and peculiar characters from the corresponding vertebræ of the *Iguanodon*, *Megalosaurus*, *Hylæosaurus*, *Cetiosaurus*, and *Streptospondylus*; and in the chief of these differences it approximates to the sub-biconcave Crocodilian type of vertebræ. As only the caudal vertebræ of the *Poikilopleuron* appear to have been hitherto discovered, I cannot avail myself of the aid, in the determination of the present fossil, which the able descriptions of M. Deslongchamps afforded in reference to the preceding one; there remains, therefore, to record the characters of the present fragment of a dorsal vertebra, in order that they may be compared with more perfect ones from the oolite of *Maladrerie* near Caen, in the event of the remainder of the vertebral column of the *Poikilopleuron* ever falling into the hands of the Palæontologist.

The present fossil is imbedded in the ferruginous sand of the Tilgate strata; its antero-posterior diameter from the extremity of the anterior to that of the posterior oblique process, is 5 inches 4 lines.

The neurapophyses, instead of rising and expanding to form a broad platform to support the spinous process, as in the *Dinosaurian* vertebræ of the Wealden, converge rapidly above the spinal canal, and support the spinous and transverse processes by a longitudinal plate not more than from 3 to 6 lines in transverse thickness; from each side of this plate a horizontal, flat, broad, lamelliform transverse process, supported below by a subvertical triangular plate, extends outwards and a little upwards; and a broad, thin, and moderately high spinous process arises, in a peculiar manner, by two laminæ, from the whole antero-posterior extent of the ridge-like summit of the neural arch. The fossil is broken in two; a portion of the centrum adheres to the anterior part of the neural arch, demonstrating the anchylosis of the two parts without trace of suture. In this respect the fossil agrees with *Poikilopleuron* and differs from *Iguanodon*, in which the neural arch is anchylosed with the centrum, but evident traces of the suture remain, at least in the dorsal vertebræ. The anterior part of the side of the centrum is impressed by a large surface for the head of the rib; the surface is concave in the axis of the vertebra, convex vertically, and is bounded above by a well-defined ridge.

The anterior oblique processes support flat articular surfaces of an elliptical form, 16 lines by 9 lines, looking upwards and inwards, their lower edges converging at an angle of 50°. These edges are separated from each other by a fissure $3\frac{1}{2}$ lines broad, continued to the base of the anterior oblique processes. In the *Iguanodon* the corresponding surfaces incline to each other at a right angle, and the lower margins of the processes are united by a continuous tract of bone. The present fossil, in the above-cited particular, resembles more the *Cetiosaurus*. Each anterior articular surface is supported by a stout process convex externally, inclining forwards and slightly expanding, so as to overhang and extend in a slight degree beyond the anterior end of the centrum: these processes are relatively lower than in the *Iguanodon*, in which also they do not extend beyond the centrum: the present fossil, in differing in these two respects from the *Iguanodon*, indicates characters which are exaggerated in the caudal vertebræ of the *Iguanodon*. A deep and narrow excavation commences immediately behind the upper and posterior origins of the anterior oblique processes, and is continued backwards, increasing in vertical extent, deep into the anterior part of the base of the spinous process. Immediately behind the columnar portion of the anterior oblique process a deep and wide conical cavity sinks, as it were, into the neurapophysis, undermining the anterior part of the base of the transverse process, and dividing the anterior oblique process from the supporting plate of the transverse process.

The transverse process commences from the summit of the neurapophysis immediately exterior to the anterior part of the base of the spinous process, by a ridge which is continued backwards from the upper and outer margin of the anterior oblique process, in a gentle curve outwards and slightly upwards. The posterior margin of the base of the transverse process is not continued, in like manner, into the posterior oblique process, but terminates or subsides into a ridge above, and separated from that process by a wide groove.

The bases of the two transverse processes are only separated from each other, owing to the modification of the neural arch above mentioned, by a thickness of bone not exceeding 4 lines: the interspace of the origins of the two transverse processes in a corresponding vertebra of the *Iguanodon* measures 4 inches; the length of the base of the neural arch being the same in the vertebræ compared.

The antero-posterior extent of the base of the transverse process in this

(presumed) vertebra of the *Poikilopleuron* is 2 inches 2 lines. The length of the transverse process is 4 inches. The vertical diameter, or thickness of the transverse process, where unsupported, is from 2 to 3 lines. It is obvious, therefore, that this long, thin, lamelliform plate of bone must need further support, in order to sustain the rib which is appended by its tubercle to the extremity; and the requisite strength is here given precisely as the carpenter supports a shelf by a bracket. The bracket-like process is a vertical triangular plate of bone, the breadth or depth of which, at its origin, is 1 inch 4 lines, and which gradually diminishes in depth and increases in thickness as it extends along the middle of the under part of the transverse process, until it is finally lost near the extremity of the process, which here has exchanged its lamellar for a prismatic form, terminating in the obtuse extremity against which the tubercle of the rib abutted. The supporting bracket is not quite vertical, but inclines a little forwards, and behind it there is a deep angular fossa. The posterior oblique processes diverge from each other and from the neural arch immediately above the posterior extremity of the spinal canal: each articular surface, which is directed downwards and outwards, forms, as it were, the base of a posterior root of the spinous process, which is convex externally, diminishing in breadth as it converges to meet its fellow at a very acute angle above a deep fissure extending forwards into the substance of the base of the spine, similarly to the fissure before described as extending backwards from the opposite part of the spine into its substance. As far as I could detach the matrix, these fissures extended so that they seem to communicate, and the neural arch to be perforated by two longitudinal passages, one for the spinal chord, and the other, running above and parallel with the former, through the base of the spinous process. This process is thus partially separated at its base into two laminæ, and presents a structure which almost realizes Prof. Geoffroy's theoretical idea of the essential nature of a spinous process, viz. that it consists of two elementary laminæ, which in fishes are superimposed one on the other, but in other Vertebrates are placed in juxtaposition.

The anterior parts of each spinal plate are thickened and rounded, like those behind, and extend to the origins of the anterior oblique processes. The diameter of this remarkable spinal fissure is from 4 to 3 lines. It is present in an inferior degree in the *Teleosaurus*, but not in the vertebræ of the *Iguanodon*, *Megalosaurus*, or other *Dinosauria*.

The base of the spinous process in this (presumed) Poikilopleuron's vertebra, instead of descending from behind forwards in a graceful curve, as in the *Dinosaurs*, forms a straight and almost horizontal line, 3 inches in extent: the spine maintains the same breadth to its summit, which is truncated rather obliquely; its height is 4 inches 9 lines, measured from the upper end of the posterior oblique processes; it is thickened and rounded at its truncate summit. The height of the spine of a corresponding vertebra of the *Iguanodon*, with a centrum of the same length, is 9 inches. Thus the present vertebra more resembles, in the form and proportions of its spinous process, as in other characters, the vertebræ of the Crocodilians.

The posterior part of the neural arch, with the spinous process of the vertebra here described, is figured in Dr. Mantell's 'Illustrations of the Geology of Sussex,' pl. xii. fig. 1, as the 'Lumbar Vertebra of the *Iguanodon*.' It is unquestionably not a lumbar vertebra; and if it does not belong to the *Poikilopleuron*, it indicates an unknown genus of Crocodilians.

In a collection of fossils belonging to S. H. Christie, Esq., from the submerged Wealden beds near the Isle of Wight, there is one half of the centrum of a dorsal vertebra from Brook Bay, which agrees in size, in the form

of the articular extremity, in the degree of median constriction, and, especially, in the large size of the medullary cavity at the middle of the bone, with the vertebral characters of the *Poikilopleuron*.

STREPTOSPONDYLUS, H. von Meyer.

Steneosaurus rostro-major, Geoffroy.—1re *Gavial d'Honfleur*, Cuv. (*vertebræ.*)

I am not aware that remains of this Crocodilian genus have hitherto been recognised in any of the British strata. The very characteristic vertebræ and jaws, of which the singular generic modifications were first described by Cuvier,* were found in the Oxford clay formation at Honfleur, and in the Kimmeridge clay at Havre. M. Hermann von Meyer likewise cites the lias of Altdorf as a depository of the fossil bones of this genus†.

The distinguishing vertebral characters are a ball and socket articulation of the bodies of the vertebræ; but the positions of the ball and cavity are the reverse of those in the existing Crocodiles, the convexity being on the anterior part of the vertebra, and the concavity directed backwards. In the anterior vertebræ, which have the ribs articulated with the body, there is a deep pit behind the costal articular surface; the transverse process rises by four salient ridges, one from each oblique process, and the two inferior and principal ones from the base of the neurapophysis; these ridges converge at an acute angle as they ascend, and meet at the under part of the transverse process, so as to include a triangular space, which is deeply concave. A third salient ridge ascends from the fore part of the base of the neurapophysis to the anterior oblique process, nearly parallel with the posterior of the two last-mentioned ridges, so that the side of each neurapophysis appears as if marked with the letter N in high relief. In the cervical and anterior dorsal vertebræ there are, instead of a single inferior spinous process, two ridges which terminate each, in front, by a tubercle, as in the vertebra dentata of the Crocodile.

Streptospondylus Cuvieri, nob.—The first fossil here to be noticed, which combines any of the above defined characters, is the anterior half of an anterior dorsal vertebra, in the collection of Mr. Kingdon of Chipping Norton: it was found in the oolite in the vicinity of that town.

The articular surfaces for the ribs are, as usual, close to the anterior part of the body of the vertebra, and this terminates by a convex articular surface, instead of being, as in the Crocodiles, concave: the second character is the remarkably deep pit behind each of the costal articular surfaces. It is as if a man had pressed his two thumbs forwards and inwards up to the first joint, into the substance of the body of the vertebra, until their extremities had nearly met. The aperture of each pit measures 1 inch by 10 lines. Sufficient of the neurapophysial arch is preserved to show the depression which has separated the two anterior ridges of its external surface; but these characteristic ridges, with the transverse, spinous and oblique processes, are broken away. The medullary canal is compressed, and gives an oval vertical section, 1 inch 6 lines high, and 1 inch 2 lines wide. Both upper and lower surfaces of the medullary canal are flat, and join the lateral surfaces at nearly a right angle. There is a slight ridge along each side of the medullary canal, indicating the neurapophysial suture, which extends here outwards and obliquely

* Ann. du Mus. xii. p. 83, pl. x. xi.

† The Saurian remains to which Prof. Bronn ('Lethæa Geognostica,' 1837, 8vo) has attached the name of *Leptocranius*, cannot belong, as he supposes, to the present genus, if it be true that the vertebræ are slightly constricted in the middle, and have both articular extremities concave, as in the following description:—"Die dazu gehorenden Wirbel-Korper in der mitte wenig verengt, vorn und hinten sind concave Gelenk-flache."—p. 517.

downwards to above the middle of the costal depression. This depression is vertically ovate, with a deeper oblique pit in the middle, 2 inches in the long diameter, by 1 inch 6 lines across the broadest part. The texture of this vertebra is coarsely cellular, except for about two lines at the margin, where it is in very compact laminæ. The anterior articular surface of the centrum is slightly and irregularly convex, being nearly flat at the upper part.

There is a slight deviation from the symmetrical figure in the whole of this vertebral fragment. The body of the vertebra is much contracted in the middle, and suddenly expands to form the terminal articular surface. This character is likewise indicated by Cuvier in his *Crocodile d'Honfleur**; thus the transverse diameter of the middle of the vertebral body, across which the present fossil has been fractured, measures 2 inches 3 lines, whilst the same diameter of the convex articular extremity is 4 inches.

The corresponding diameters of one of the anterior dorsal vertebræ of the *Streptospondylus*, described by Cuvier, are respectively 1 inch 7 lines, and 2 inches 6 lines; whence we may conjecture that the length of the entire vertebra here described would have been 4 inches and a half. The vertical diameter of the articular surface is 3 inches 9 lines.

The non-articular surface of the vertebral body is smooth, except near the articular extremity, where it is rather coarsely rugous. The inferior ridges and tubercles have disappeared at the part of the vertebral column to which the present vertebra has belonged.

The osseous substance of the present fossil, like that of the bones of the *Streptospondylus* from Honfleur, presents a deep chocolate brown hue, and takes a bright polish. It is not completely mineralized; the small cavities of a great part of the diploë are empty, and not filled with semitransparent calcareous spar, as in the Honfleur specimens.

With the portion of the vertebra above described there was associated the extremity of a spinous process, which gradually expands to a rough obtuse quadrilateral summit. This spine is characterized by having a very rugged and thick ridge, developed from the anterior and posterior surface of what may be regarded as the ordinary spinous process, the sides of which are smooth, except near the summit.

	Inches.	Lines.
The length of this fragment of spine is	3	8
The transverse diameter of the base	0	9
The transverse diameter of the summit of the apex	1	6
Antero-posterior diameter of spine	1	3
Ditto, including the ridges	1	10

In the Crocodile a thin plate is continued from the anterior and posterior edges of the thicker spinous processes; but the *Streptospondylus*, if I am correct in attributing this spinous process to that genus, presents an extreme and peculiar development of this structure.

A portion of a compressed, conical, hollow tooth, with a brown dense glistening dentine, covered by smooth enamel, and resembling that of the *Megalosaurus*, was associated with the preceding vertebra. The length of this fragment of tooth is 2 inches 4 lines, but both ends are wanting. The breadth is 8 lines; the thickness 5 lines†. If it really belong to the *Streptospondylus*, it confirms the view of the affinity of that genus to *Megalosaurus*, which has been suggested by the characters of the vertebra. With the above fractured vertebra and tooth there were likewise found, in the oolite at Chipping

* "Le corps de cette vertèbre, ainsi que des suivantes, est beaucoup plus rétréci dans son milieu que dans les Crocodiles connus."—Ossem. Foss. ed. 1824, tom. v. pt. 2. p. 156.

† The teeth conjectured by Cuvier to belong to the *Honfleur Streptospondylus* are conical and striated.

Norton, a portion of a broad flat bone, with a convex, rough, articular labrum, nearly two inches thick, and of a fine cancellous structure, and fragments of long bones, with large medullary cavities and compact outer walls, of which the thickness equals about one-third of the diameter of the medullary canal.

A more perfect specimen, referable to the present genus, is a posterior dorsal vertebra from the jet-rock (lias shale) near Whitby, and forms part of the collection of fossils of Mr. Ripley, surgeon of that town.

It is much more complete than the preceding specimen, wanting only the spinous and transverse processes; there is a slightly raised oval surface for the articulation of the head of the rib, on each side of the body, at its upper and anterior part, in the corresponding situation with that for the head of the rib on the four anterior dorsal vertebræ in the existing Crocodiles: this surface in the Whitby vertebra is relatively smaller and lower down than in the larger specimen of *Streptospondylus* from the oolite.

The present specimen nearly corresponds in size with the dorsal vertebræ of the Honfleur *Streptospondylus* described by Cuvier*, as will be seen by the following admeasurements:—

	Whitby.		Honfleur.	
	Inches.	Lines.	Inches.	Lines.
Length, or antero-posterior diameter of body .	3	5	3	8
Transverse diameter of articular surface . . .	3	0	3	3
Transverse diameter of middle of body . . .	1	3	1	6

The principal character of the vertebræ of *Streptospondylus*, viz. the anterior ball and posterior cup, is unequivocally demonstrated in this specimen by the presence of the oblique processes, which determine the anterior and posterior extremities of the vertebra; the two articular surfaces which look upwards and inwards correspond with the convex extremity of the body of the vertebra; while those on the oblique processes, which look downwards and outwards, overhang the extremity of the body of the vertebra, which is excavated by a moderately deep and regular concavity.

To judge from the figures of two of the vertebræ of the *Streptospondylus*† from Honfleur, the characteristic fossa on each side of the body becomes shallower, and situated nearer the middle of the side of the body as the vertebræ approach the tail; but the lateral fossæ present both these modifications in the Whitby vertebra, which, from the articular surface of the rib, would seem to have come from the anterior part of the dorsal region of the spine.

This vertebra presents the minor generic characters of the *Streptospondylus* in the length of the body, its lateral compression and inferior concavity, the two extremities being expanded to form the articular surfaces. The non-articular surface is smooth, except near the margins of the articular extremities. The line of the hæmapophysial suture extends horizontally the whole length of the centrum. The two characteristic lateral buttress-like ridges rise from the two extremities of the base of the neurapophysis, and converge to the under part of the base of the transverse process, where they meet; the depressions between and on each side of these ridges are deep: the third ridge extending from the anterior part of the base of the neurapophysis to the anterior oblique process stands out in nearly as bold relief as those which support the transverse process.

The articular surfaces on the oblique processes are bounded by a regular convex free margin; their long diameter is 1 inch 10 lines, their short diameter 9 lines; they are nearly flat: the anterior ones look inwards and upwards; the posterior downwards and outwards.

* *Loc. cit.*, p. 308. † Ossem. Foss. v. pl. ix. fig. 3 and 10.

The two superior ridges, extending from the upper part of the anterior and posterior oblique processes to the transverse process of the same side, describe a regular concave curve.

The vertical diameter of the fractured transverse process is 1 inch 3 lines, its transverse diameter is 1 inch.

The great development of the superior part of the neural arch, and the strength and high relief of the buttress-like ridges supporting and strengthening the different processes, indicate that the spinous process was unusually large and massive. This process was not preserved in any of the vertebræ of the Honfleur *Streptospondylus* described by Cuvier, nor, unfortunately, in the present vertebra; but its otherwise more perfect state adds another character to those by which the vertebræ of the *Streptospondylus* deviate from the Crocodilian type; viz. a broad plate of bone extended transversely between the two posterior oblique processes, and increasing in breadth as it ascends. The base from which the spinous process should rise, which is thus bounded by the oblique and transverse processes, extends beyond, and, as it were, overhangs the whole body of the vertebra below; and is hardly less remarkable for the height to which it is carried above the body.

Thus from the highest part of the posterior oblique process to the lower margin of the corresponding articular surface of the vertebral centre measures 6 inches; the length of the vertebral centrum being 3 inches 5 lines: the contrary proportions prevail in the posterior dorsal and lumbar vertebræ of the existing Crocodiles. The breadth of the neural arch, where the lateral buttresses terminate at the base of the transverse processes, is 6 inches.

Streptospondylus major, nob.—The third British formation in which I have determined the remains of the genus *Streptospondylus* is the Wealden; the specimens having been obtained from three localities, viz. Tilgate Forest in Sussex, and Brook Point and Culver Cliff in the Isle of Wight. The specimens differ in size from those already described, being larger than the *Streptospondylus Cuvieri* from the oolite; I strongly suspect that they indicate a distinct species, but the means of comparison for the satisfactory establishment of the distinctions are as yet wanting. M. H. von Meyer has added nothing but the generic name to the observations of Cuvier, on which the claims of the present extinct Crocodilian to generic distinction are founded: these observations were taken from the dorsal vertebræ, atlas and axis, whilst the most characteristic of the Wealden vertebræ appertain to the middle part of the cervical region, from whence vertebræ of the reversed ball and socket system have not been hitherto recognized.

These vertebræ I apprehend to be those on which Dr. Mantell has founded his description of the "Fourth system" from the Wealden. He says, "The vertebræ of the fourth system (fig. 4) are very rare, only six or seven have come under my observation. They are of the true Lacertian type, having the articular facets of the body convex posteriorly and concave anteriorly, and are *wider than high*, as in the Iguana and Monitors, and not in the reverse proportions, as in the recent Crocodiles. In two large but mutilated cervicals, the admeasurements are as follow:—

	Inch.
"Height of the concave extremity	$3\frac{1}{2}$
Width of the same	$4\frac{1}{2}$
Length of the body	6

"It is not obvious whether the annular part be divided by suture or otherwise; the articular apophyses are horizontal and very strong; the spinous process is destroyed *."

* Mantell's Geology of the South-east of England, 8vo, 1833, p. 300.

It is the fortunate preservation of the two articular, or oblique processes, at one of the extremities of the annular part of this fine cervical vertebra, now in the Mantellian Collection, British Museum (No. $\frac{116}{2116}$), that has enabled me to correct the error into which the Founder of that noble collection has, in this instance, fallen: the flat oblong articular surface of each of these strong and well-marked oblique processes looks downwards and outwards, determining them to be the *posterior* pair; and they overhang the concave extremity of the body of the vertebra, determining that to be the *posterior* extremity. The opposite, or *anterior* end of the body of the same fossil, is convex. The few other large convexo-concave vertebræ from the Wealden of Tilgate correspond with the one here described in these important characters of the genus *Streptospondylus*, and equally differ from the vertebræ of the *Iguanæ*, *Monitors*, and all other existing *Sauria*. Of the fossil cervical vertebra, 6 inches long, the anterior extremity of the body is further indicated by the position of the costal tubercle, or transverse process, which is developed as a strong obtuse ridge from the middle part of that half of the centrum which is nearest the convex articulation. Beneath this ridge the sides of the body are concave, and converge to a broad ridge, which terminates the anterior part of the lower surface of the vertebra, and corresponds with the process given off from that part in the cervical vertebræ of the Crocodile. A second concavity, at the upper part of the side of the body, separates the transverse process, or ridge, from the base of the neural arch; from which a second, or upper transverse process is developed for the attachment of the tubercle of the rib.

The neural arch has been crushed down upon the centrum, and its anterior oblique processes and spine are broken away; the upper, non-articular part of the strong diverging posterior oblique processes is convex.

In the museum of Mr. Saull, F.G.S., Aldersgate Street, there is a cervical vertebra of the great *Streptospondylus* associated, as in the Mantellian Collection, with vertebræ of the *Iguanodon* and *Cetiosaurus*, all of which have been washed out of the submarine Wealden beds at the south side of the Isle of Wight, and thrown on shore near Culver Cliffs and Brook Point.

The lower half of the sides of the centrum of the vertebra of the *Streptospondylus* are, like the preceding vertebra from Tilgate, concave and obliquely compressed, so as to converge to the anterior part of the under surface, which thus presents a triangular form, with the apex forming the obtuse anterior ridge, and the base turned backward and somewhat flattened. Each lateral concavity is bounded above by a short but broad transverse process, developed from the anterior half of that part of the centrum, and terminated by an oblong flattened surface for the articulation of the head of the cervical rib; which surface is about twice as long in the antero-posterior as the vertical direction. Above this process the centrum is again concave. The base of the neurapophysis is anchylosed to nearly the whole antero-posterior extent of the centrum, the course of the original straight suture being readily discernible. An upper transverse process is developed from the side of the base of the neurapophysis, affording a broader surface for the tubercle of the cervical rib than does the lower transverse process. Above the upper transverse process the neurapophyses converge obliquely to the base of the spinous process. The line of the base of the spine inclines forwards, and the thickness of the spine diminishes in the same direction. The difference in the height of the neural arch, and in the configuration of its external surface, which both the cervical vertebræ of the great Wealden *Streptospondylus* present, when compared with the dorsal vertebræ of the smaller specimens from the older oolite formations, is very great; and the more remarkable, as in the

existing Crocodiles the height of the neurapophyses is greater in the cervical than in the dorsal region: as, however, the transverse processes in the Crocodiles come off from a higher part of the neural arch in the dorsal than in the cervical vertebræ, the spine of the great Wealden *Streptospondylus* may possibly present modifications in the dorsal region corresponding with those remarkable ones which have been already described in the Whitby vertebra.

The posterior articular processes in the cervical vertebra from Culver Point, are similar in all respects to those in the Tilgate specimen, and equally determine the fore and hind extremities of the vertebra.

The following are admeasurements of the bodies of the two vertebræ of the Wealden *Streptospondylus*:—

	Tilgate.		Culver Cliff.	
	Inch.	Lines.	Inch.	Lines.
Transverse diameter of posterior concave articular surface	5	0	6	0
Vertical diameter of posterior concave articular surface	3	6	4	6
Antero-posterior diameter	6	0	5*	0
Transverse diameter of the body across the inferior transverse processes	6	0	6	6
Height from lower surface of centrum to the hind part of base of spine			7	9
Antero-posterior extent of lower transverse process	2	2	2	4
Interspace between upper and lower transverse processes			2	0

In the museum of the Geological Society of London there is a collection of rolled vertebræ from the coast at Brook Point, Isle of Wight, which, among the bones of *Iguanodon* and other gigantic Wealden genera, contains the centrum or body of a dorsal vertebra of the great *Streptospondylus*. This specimen, though much rolled and worn, is interesting, inasmuch as it exhibits the characteristic contraction of the middle and expansion of the ends of the centrum, together with unequivocal evidences of the marked depression on each side, near the upper part of the anterior or convex end of the centrum. What remains of the depression is about the size of the end of a man's thumb. The convexity of the anterior extremity resembles in degree, and likewise in irregularity, that in the fractured vertebra of the *Streptospondylus* from the oolite, in Mr. Kingdon's collection.

The present centrum is less depressed than those of the cervical region, but agrees with them in length, as the following dimensions show:—

	Inches.	Lines.
Antero-posterior diameter	5†	0
Vertical diameter of concave end	5	6
Transverse diameter of concave end	5	3
Transverse diameter of middle of centrum	3	0

The vertebra from the forest marble alluded to in the note at p. 297 of Dr. Mantell's 'Geology of the South-east of England,' is a centrum from the posterior part of the dorsal region of the *Streptospondylus major*.

The determination of the true nature of the convexo-concave vertebræ of the Wealden, and of the affinities of the reptile to which they belonged, besides extending our knowledge of the gigantic oviparous animals of that

* It is evident that an inch at least, perhaps more, has been chiseled away from the ball which terminated the anterior end of the body of the specimen in Mr. Saull's collection.

† The margins of the extremities being worn and rounded prevent the actual length being given.

epoch, removes one of the chief difficulties attending the determination of the true vertebral characters of the *Iguanodon*. For if gigantic vertebræ, agreeing in the important character of their articular surfaces with the existing *Iguanæ*, had actually been discovered, though of rare occurrence, associated with teeth of corresponding dimensions, but similar in form to those of the Iguana, there would have been strong ground for suspicion, that such vertebræ and teeth might be parts of the same species *

The elimination of these, otherwise perplexing, ball and socket-jointed vertebræ, and their identification with the peculiar Crocodilian genus of Honfleur, on which M. H. von Meyer has imposed the name of *Streptospondylus*, forms, therefore, an essential step in the appropriation to the *Iguanodon* of its true vertebral characters.

Cetiosaurus.

Cetiosaurus brevis, nob.—The attempt to reduce to order the various forms and types of vertebræ, which the Wealden strata have yielded to test the sagacity of the interpreters of its organized treasures, was one of Dr. Mantell's earliest labours, and he states † that his first step was, with the able assistance of the Rev. W. D. Conybeare, to separate those that belonged to the Crocodile, *Plesiosaurus* and *Megalosaurus*, or rather which resembled those from Stonesfield. Many enormous vertebræ then remained, from which those belonging to the *Iguanodon* were to be chosen; from these residuary specimens the characteristic ones of the *Poikilopleuron* and *Streptospondylus* have already been eliminated, and I next proceed to remove from them the vertebræ which characterize the genus *Cetiosaurus*.

Of the existence of vertebræ of this genus in the Wealden strata, I first became acquainted by the examination of Mr. Saull's collection of sea-rolled fossils washed out of the submerged Wealden beds, and deposited on the shores of the Isle of Wight, at Sandover Bay.

The vertebræ in question present the well-marked generic characters of those of the dorsal region in the *Cetiosaurus*, as the breadth of the centrum, its subcircular contour, its median contraction and unequal concavity of the articular extremities; as, also, the short antero-posterior extent of the neurapophysis, and their anchylosis to the anterior part of the upper surface of the centrum: but they differ from the vertebræ on which the characters of the present genus were first founded ‡ by the shortness of their antero-posterior diameters as compared with their breadth and depth, whence I propose to designate the species by the name of *Cetiosaurus brevis*.

The centrum of a dorsal vertebra of this species from Culver Cliff measures,

	In.	Lines.
in antero-posterior diameter	3	6
transverse diameter	6	4
vertical diameter	6	0

* This suspicion is expressed, but with due caution, by Dr. Mantell in his 'Geology of the South-east of England.' "The somewhat angular vertebræ, described as appearing to constitute a Second System, I should be disposed, from their number, and from their so commonly occurring in the localities where the teeth of the *Iguanodon* most abound, to refer to that animal; it must, however, be mentioned, that the concavo-convex vertebræ which correspond so entirely with those of the Iguana and Monitor, would seem to offer a more probable approximation; yet the extreme rarity of the latter renders it questionable, since there appears no reason why the vertebræ should not have been preserved in as considerable numbers as the teeth."—p. 306. The vertebræ of the *Iguanodon* discovered by Mr. Benstead in the greensand quarries near Maidstone, are so crushed or so imbedded, as to prevent a satisfactory determination of both articular extremities.

† Illustrations of the Geology of Sussex, 4to, 1827, p. 76. Geology of the South-east of England, 8vo, 1833, p. 278.

‡ See Proceedings of the Geological Society for June 1841.

One of the articular ends * is rather more concave than the other, which, from the wearing away of the margins, appears slightly and unevenly convex. The contracted middle part of the vertebra is concave lengthwise, and pretty regularly convex in the direction transverse to the axis of the vertebra: the free surface is finely striated, and perforated here and there by vascular foramina: there is no lateral depression. The neurapophyses were broken off; their bases, instead of having their long diameter corresponding with the axis of the vertebra, as in *Iguanodon*, present it in the direction transverse to that axis, as in *Plesiosaurus*: they do not quite meet at the middle of the upper or neural surface of the centrum, but are there divided by a narrow longitudinal tract forming the lower part of the spinal canal.

The antero-posterior extent of the anchylosed base of the neural arch is 2 inches 6 lines: the transverse diameter, 5 inches.

Two caudal vertebræ of the same species, also from Culver Cliff, present the same length and unequal concavity of the articular extremities; the anterior one, here determinable by the anterior position of the narrower hæmapophyses, being the deepest: the sides of the body are more compressed, and more convergent towards the under surface; so that, as the expanded margins of the articular ends are worn away, the centrum presents rather a triangular than a subcircular contour. The disproportion of its antero-posterior with its transverse and vertical diameters, distinguishes it from the caudal vertebræ of the *Iguanodon*. The neurapophysis rises from the anterior three-fourths of the centrum, and sends forwards a subprismatic anterior oblique process, but does not develope a posterior one: it then contracts, and inclines to the base of the spine, which is much shorter than in the *Iguanodon*. The spinous process inclines backwards from the vertical axis of the centrum at an angle of 45°. A short transverse process is developed from the junction of the neurapophysis with the centrum. The hæmapophysial surfaces appear single on both the anterior and posterior parts of the lower surface; they are nearly flat, and slope towards each other.

	In.	Lin.
Antero-posterior diameter	3	0
Transverse diameter	5	0
Vertical diameter	5	0
Height of vertebra to summit of spine† .	12	9
Antero-posterior diameter of spine . . .	2	10
Thickness at posterior part of base . . .	1	0
Height of spine, 1st caudal	5	0
Height of spine, 2nd caudal‡	4	0

The characters and dimensions of these rolled vertebræ of *Cetiosaurus* from the submarine beds of the Wealden formation, although somewhat obscured by the circumstances under which they are brought to light, are sufficiently satisfactory to establish their generic character, and to give an useful approximative idea of their size and proportions. The corresponding bones from the Wealden of Tilgate Forest supply, by their more perfect state of preservation, the deficiencies of the Isle of Wight specimens, and further establish the co-existence of the *Cetiosaurus* with the *Iguanodon*, *Streptospondylus*, *Megalosaurus* and other extraordinary reptiles of that period. The vertebræ of the *Cetiosaurus brevis* in the Mantellian Collection are the

* Subsequently determined by more perfect specimens to be the posterior surface.

† This is rounded off, but seems not to have been broken.

‡ The 1st and 2nd do not here refer to the place of these vertebræ in the tail; but if the vertebræ were contiguous in the entire animal, the tail must be much shorter than in the *Iguanodon*.

most gigantic specimens of Saurian remains that enrich it. They include the bodies of two dorsal vertebræ and four entire caudal vertebræ, which, if not consecutive, seem to have come not from distant parts of the basal portion of the tail of the same individual; there are also the bodies of several of the smaller posterior caudal vertebræ.

No. $\frac{133}{2133}$ ("Gigantic vertebra of *Iguanodon*," MS. Catalogue of Mantellian Collection,) is a posterior dorsal vertebra of the *Cetiosaurus brevis*, and exhibits in a striking manner the peculiar characters of this species, viz. the great depth and breadth, especially the latter dimension, as compared with the length or antero-posterior diameter of the centrum or body of the vertebra.

The posterior articular facet is, in this region of the spine, more concave than the anterior surface, a structure which approximates to that peculiar one which characterizes the *Streptospondylus* *. The contour of the articular ends is a full transverse oval: the middle of the centrum is strongly contracted, slightly concave in the longitudinal direction at the upper part of the side of the centrum, but deeply concave below, and with a slight indication of a broad, obtuse longitudinal ridge along the middle of the concave under surface. In the *Iguanodon* the sides of the vertebral body are nearly flat in the vertical direction; in the *Cetiosaurus* they are strongly convex. The surface at the middle of the vertebra is longitudinally striated with very fine, subparallel, short impressions: these grow deeper and more irregular at the thick, rugged and everted margins of the articular ends.

The neurapophyses are firmly anchylosed here, as in the caudal region, and the line of the primitive suture is hardly discernible: their base is shorter than the short centrum, and is attached nearer its anterior part: in the *Iguanodon* the neural arch is very nearly coextensive in antero-posterior diameter with the centrum supporting it: in a dorsal vertebra, of an *Iguanodon* $4\frac{1}{2}$ inches in breadth, the antero-posterior extent of the base of the neural arch is 4 inches: in the present vertebra, which exceeds 7 inches in breadth, the antero-posterior extent of the base of the neural arch is $2\frac{1}{2}$ inches, and only 2 inches a little above the base. The outer side of the neurapophysis is convex in the axis of the vertebra, and concave in the opposite direction as it ascends to the base of the transverse process, without exhibiting a trace of the ridges and hollows that so singularly characterize the same part in the dorsal vertebræ of the *Streptospondylus Cuvieri*. The antero-posterior diameter of the base of the transverse process is 2 inches; its vertical diameter 1 inch. The diameter of the spinal canal is 1 inch 9 lines. The articular surfaces of the anterior oblique processes are flat, and look upwards and slightly inwards. In the *Iguanodon* their under margins, in the dorsal vertebræ, converge at nearly a right angle: in the present vertebra they incline to each other at an angle of 40°. The spinous process begins to rise immediately behind the anterior oblique processes by a narrow vertical plate, which seems as if it

* Since the vertebræ of the *Streptospondylus* lose their peculiar convexo-concave character by the gradual subsidence of the anterior ball, as they approach the tail, the cervical vertebræ of the *Cetiosaurus* may approach, more nearly than do the dorsal ones, to the convexo-concave structure of the Streptospondylian vertebræ. The fact that, hitherto, only cervical vertebræ of the great *Streptospondylus*, and only dorsal and caudal vertebræ of the *Cetiosaurus*, have been discovered in the Wealden formations, has induced me well to consider the grounds for assigning them to Saurians of distinct genera. But the general constancy of the vertebræ of the same Saurian in their antero-posterior diameter, forbids the supposition of a vertebra of six inches in length in the neck being associated with one of three inches in length in the back. Additional evidence of a very decisive character must at least be obtained before the great Cetiosaur can be admitted to have resembled the Pterodactyle in such disproportionate length of the cervical vertebræ.

were nipped in between two shallow depressions; its base ascends obliquely, and grows thicker to the posterior part of the neural arch. The summit is not entire.

The height of this dorsal vertebra to the posterior origin of the spinous process is $9\frac{1}{2}$ inches: from the base of the neurapophysis to the upper part of the transverse process, measures 3 inches.

No. "$\frac{115}{2115}$" in the Mantellian Collection, ("Vertebra of *Iguanodon*, 8 inches in diameter," MS. Catalogue), may have actually presented that dimension when entire, for even now, not allowing for the margin of the posterior articular surface which has been broken away, it measures 7 inches across that surface. This remarkable specimen, which may probably have afforded the type of the 'third or plano-concave' vertebral system, in the summary of the vertebral characters of the Wealden reptiles given by Dr. Mantell in his 'Geology of the South-east of England*,' and which accords best with the characters assigned by M. H. von Meyer to the vertebræ of the *Iguanodon*†, presents, in fact, in a striking degree, those of the vertebræ of the *Cetiosaurus*, and belongs to a more posterior part of the dorsal region, perhaps to the loins, of the same individual, certainly to one of the same species, as the vertebra (No. 2133) last described.

The anterior articular extremity makes the same approach to a plane surface, being slightly concave below and very slightly convex above: the depth of the posterior concave surface at the centre is 9 lines. The general contour of the centrum has begun to change from the circular to the subquadrate, which latter figure is more decidedly expressed in the anterior caudal vertebræ of the *Cetiosaurus brevis*.

The upper half of the sides of the centrum are more concave in the axis of the vertebra than in No. 2133. The free surface presents the same degree of smoothness, and is pierced here and there by moderate-sized vascular foramina. The spinal canal makes a slight depression in the upper part of the centrum: in the *Iguanodon* it is encompassed by the bases of the neurapophyses. The transverse diameter of the spinal canal is 1 inch, which small dimension satisfactorily distinguishes the present enormous vertebra from those of the mammiferous class, viz. the Cetacea, to which in other respects it has the greatest similitude. The antero-posterior diameter of the base of the neurapophysis is 2 inches.

The four anterior caudal vertebræ in the Mantellian Collection, which are here assigned to the *Cetiosaurus brevis*, slightly increase in antero-posterior diameter, as is the case in the *Cetiosaurus medius*, as they recede from the trunk, which seems to indicate that the present gigantic marine Saurian must have had a capacious and bulky trunk, but propelled by a longer and more Crocodilian tail than in the modern whales. It is sufficiently evident, however, that, even in the present short segment of the tail, with the slight increase of length, there is a diminution of height and breadth of the centrum, and a still more obvious subsidence of the neural arch, as the vertebræ recede from the trunk. As compared with the dorsal vertebræ, the chief change of form is the subquadrate contour produced by a lateral extension and flattening of the lower surface of the centrum, which is more essentially distinguished by four hæmapophysial articular surfaces, two at the anterior and two at the posterior margins of this inferior surface. The articular surfaces at both ends of the centrum are now concave; and the anterior one, which was nearly flat in the dorsals, is here the deepest; it is one inch deep at the upper third of

* 8vo, 1833, p. 296, fig. 3.

† Palæologica, p. 212.

the surface*. The sides of the centrum at the upper half are concave both lengthwise and vertically, forming a wide depression below the transverse process; the middle part of the side begins to stand out and divide the upper from the lower lateral concavity, which character, being more strongly developed in the hinder caudal vertebræ, gives the rhomboidal or hexagonal form†. The lower half of the side of the centrum is less concave than in the dorsal vertebræ. The broad inferior surface is also less concave antero-posteriorly than in the dorsal vertebræ, and is nearly flat transversely: it gradually contracts, in the transverse direction, in the posterior caudals, so as to take on the form of a longitudinal sulcus. The two anterior hæmapophysial surfaces are separated from each other by an interval of two inches; the two posterior surfaces, which are larger than the anterior ones, are similarly distinct.

In the *Iguanodon* the hæmapophysial surfaces are confluent on both the anterior and posterior parts of the under surface of the centrum, and the chevron bones accordingly present modifications by which they may, when detached, be distinguished from those of the *Cetiosaurus*.

The transverse processes have descended, as usual, from the summit to the base of the neural arch in the present anterior caudal vertebræ. They are short, compressed vertically, diminishing, and as if slightly twisted, so that the upper margin is turned forwards, at their extremity. The vertical diameter of the base of the transverse process in the largest of the present caudal vertebræ is three inches; its anterior-posterior diameter one inch six lines; its length two inches seven lines: the extremity terminates obtusely. The upper ridge-like termination of the transverse process is continued to the base of the anterior oblique processes. These processes are alone developed in the present vertebræ, the posterior articular surfaces being impressed upon the sides of the posterior part of the base of the spine. The anterior oblique processes project almost horizontally forwards, diminishing, chiefly in vertical diameter, to an obtuse apex; convex externally, flattened internally by the oblong articular surface, and separated by a fissure nearly one inch wide: the length of these processes, from the bottom of the intervening fissure in the second of the four caudals, where they are most entire, is two inches. When the vertebræ are placed in juxtaposition, these processes reach beyond the middle of the vertebræ next in front, and pinch, as it were, the back part of the base of the spine so as to impress upon it the surfaces representing the posterior articular processes. These processes are well developed, on the contrary, in the corresponding vertebræ of the *Iguanodon*, and overhang the posterior surface of the body of the vertebra to which they belong. The spinous process, which appears to be nearly perfect in the second caudal, is short, strong, and truncated at the summit. Its height from the anterior oblique processes is four inches: the total height of the vertebra is thirteen inches. The antero-posterior diameter of the side of the neural arch is two inches. The spinal canal is wider in these caudal than in the dorsal vertebræ, indicating the greater muscularity of the part deriving its nervous power from the corresponding part of the spinal chord: its transverse diameter is one inch ten lines; its vertical diameter is two inches. The neural arch is, as usual in the present genus, anchylosed to the anterior part of the upper surface of the centrum: one inch and a half of this surface is left free behind the attachment

* The same modification of the articular extremities occurs in the caudal region of the vertebral column of the *Plesiosaurus*. See 'Report on Brit. Foss. Reptiles,' part i. Trans. Brit. Assoc. 1839, p. 58.

† It is one of these posterior caudals of the *Cetiosaurus*, which is figured as the type of the "second vertebral system" in the 'Geology of the South-east of England,' p. 296, fig. 2.

of the arch. The finely wrinkled or fibrous character of the free surface is more strongly marked in these caudal than in the dorsal vertebræ.

In the three succeeding vertebræ the neural arch diminishes in height, the anterior articular processes diminish in length, and the posterior articular impressions in depth. The upper and lower parts of the sides of the body become somewhat more concave; the posterior articular surface grows flatter.

A detached chevron bone, eight inches in length, consisting of two hæmapophyses, anchylosed only at their distal or inferior extremities, and with their distinct proximal ends more divaricated than are the confluent ones in the *Iguanodon*, corresponds with the caudal vertebræ here described, and doubtless belongs to the *Cetiosaurus brevis*.

The following are dimensions taken from the four caudal vertebræ above described:—

	1st.		2nd.		3rd.		4th.	
	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.
Antero-posterior diameter of centrum .	3	9	4	2	4	3	4	3
Transverse diameter of centrum . .	7	2	7	1	6	9	6	4
Vertical diameter of centrum . . .	6	10	6	8	6	0	6	0

Of the present species of *Cetiosaurus*, I have examined specimens of the bodies of one dorsal and three posterior caudal vertebræ in the collection of Gilpin Gorst, Esq., which were obtained from the central strata of the Wealden, near Battle Abbey, commonly called the 'Hastings beds.'

The dorsal centrum closely agrees with those in the Mantellian Collection: its anterior surface is, as in them, nearly flat, or slightly convex; the posterior surface is concave.

	In.	Lines.
The antero-posterior diameter	3	2
The transverse diameter of the anterior surface . . .	5	3
The vertical diameter of the anterior surface	5	2

A fracture of this centrum through its middle shows it to consist throughout of a coarse cellular texture. The neurapophyses, with an antero-posterior extent of base of two inches three lines, are continuously anchylosed with the centrum, as in Mammalia, and leave about three quarters of an inch of the posterior part of the centrum free. The lower part of the spinal canal is horizontal; its transverse diameter one inch three lines.

The posterior caudal vertebræ present an antero-posterior diameter of nearly four inches, with a breadth of three and a half inches, and a depth of four inches, measuring to the lower part of the posterior hæmapophysial surface. The antero-posterior length of the base of the neurapophysis is two inches two lines; and it does not begin so close to the anterior part of the centrum as in the dorsal vertebra. The upper and lower portions of the side of the centrum are more distinctly separated by the comparative projection of the middle part, which gives the obscurely hexagonal form to these vertebræ. The inferior parts are most concave, and converge to form the sides of the longitudinal sulcus, to which the inferior surface of the centrum is reduced at this part of the tail. It is plain, from these modifications of the vertebræ, that the tail must here have presented the compressed Crocodilian type; and it is satisfactory to have these indications of the Saurian affinities of the present gigantic fossil, in consequence of the very close approximation of the larger vertebræ to the Cetaceous type. The vertical extent of the osseous basis of the tail was here augmented by strong hæmapophyses, which have left more prominent articular facets on the under part of the centrum than in the larger anterior caudal vertebræ: these facets, instead of being in pairs, are confluent at the anterior, and at the posterior ends of the lower sur-

face; the posterior confluent pair, forming a triangular prominent surface, inclining obliquely forwards, and with its apex notched by the termination of the inferior sulcus.

There are several posterior caudal vertebræ of the *Cetiosaurus brevis* in the Mantellian Collection, which closely correspond with those just described from the Hastings beds; four of these vertebræ give the following dimensions:—

	Nos. 2112.		2142.		2153.			
	In.	Lin.	In.	Lin.	In.	Lin.	In.	Lin.
Antero-posterior diameter of centrum . .	4	3	3	10	3	7	3	0
Transverse diameter of its articular end .	3	10	3	0	2	8	1	4
Vertical diameter of its articular end . .	4	0	3	3	3	0	1	5
Vertical diameter at middle of the centrum	4	6	3	11	3	10	1	2

The vertebræ figured in the 'Illustrations of the Geology of Sussex,' pl. ix. fig. 8, and pl. x. fig. 1, are posterior caudal vertebræ of the *Cetiosaurus brevis*.

Cetiosaurus brachyurus.—A dorsal and a caudal vertebra from the Wealden formation at Tetham, which agree in essential characters with the *Cetiosaurus*, and differ from those of *Streptospondylus*, *Megalosaurus*, *Iguanodon*, *Hylæosaurus*, *Poikilopleuron*, and the Crocodilian vertebræ of the Wealden, offer at the same time proportions which forbid their reference to the *Cetiosauri brevis*, *medius* and *longus*, and indicate a species distinguished by a shorter tail.

The dorsal vertebra (No. $\frac{109}{2109}$, Mantellian Collection) presents a subcircular centrum, with the neurapophyses anchylosed, but broken off; they are shorter than the centrum, and leave eight lines of its hind part uncovered. The anterior articular surface of the body is slightly convex at the upper, and concave at the under half: the posterior surface is uniformly concave: the body is constricted at the middle, but in a less degree than in the *Cetiosaurus brevis*, so that it is less deeply concave lengthwise: it is as convex transversely: a slightly-raised obtuse ridge separates two shallow sulci at the under surface of the vertebra.

The caudal vertebra (No. $\frac{161}{2161}$, Mantellian Collection) presents a shallow and rather oblique sulcus along the lower surface. The hæmapophysial articulations are most marked at the posterior part of this surface. The sides of the centrum are less concave longitudinally than in the dorsal vertebra; there is a vascular perforation on each: the articular ends of the body agree with those of the dorsal vertebræ. The following are dimensions of the preceding vertebræ:—

	Dorsal.		Caudal.	
	In.	Lin.	In.	Lin.
Antero-posterior diameter of body . . .	3	0	2	9
Vertical diameter of articular end . . .	4	3	3	10
Transverse diameter of articular end . .	4	6	3	7

These vertebræ closely corresponded in texture and character of the external surface*.

Cetiosaurus medius.—The remains of this Reptile have hitherto been discovered only in the oolitic strata below the Wealden. They appear to have been first noticed in a letter from John Kingdon, Esq., read at the meeting of the Geological Society held June 3rd, 1825, in which "he mentions the situation in which certain bones of a very large size, appearing to have belonged to a whale and a crocodile, were lately found completely imbedded in the oolite quarries (lower oolite), about a mile from Chipping Norton, near Chapel House." It is principally on these bones, with others subse-

* They are probably the bones alluded to in the Note at p. 221 of Dr. Mantell's 'Geology of the South-east of England.'

quently discovered and in the collection of Mr. Kingdon, that the characters of the *Cetiosaurus* were first determined*. They include a portion of the tail consisting of ten vertebræ; the anterior and larger ones were five inches and a half in length, seven inches across the articular surface at each end of the body, and not less than two feet in vertical diameter, including the neural (superior) and hæmal (inferior) spines. Both articular extremities are concave, the anterior one being rather the deepest; but the difference is less than in the *Cetiosaurus brevis*. The articular cavities become shallower in the posterior caudal vertebræ; these gradually diminish in transverse and vertical diameter, but retain the same length, even when they are reduced to two inches and one inch and a half in breadth. The body of the vertebra has no central cavity, in which respect the present, like the preceding species of *Cetiosaurus*, may be distinguished from the *Poikilopleuron*, where such cavity exists. The neurapophysis does not equal in antero-posterior extent the centrum or body of the vertebra, the disparity increasing in the posterior caudal vertebræ: the arch is placed towards the anterior end of the vertebra. The hæmapophysial arch has a less contracted base than in the *Iguanodon*, and the proximal extremities of the hæmapophyses are free, as in the *Cetiosaurus brevis*.

One of the ungual phalanges, which is conical, subcompressed, and slightly curved, is traversed on each side by the usual vascular groove, curved with the convexity upwards, measuring five inches in length, and three and a half across its articular base. The bone alluded to in Buckland's 'Bridgewater Treatise,' vol. i. p. 115, and figured in Mr. Lyell's 'Elements of Geology' (1838), p. 384, is a metatarsal of the *Cetiosaurus*. This fossil was found in the great oolite of Enstone, near Woodstock.

A few large caudal vertebræ, and other bones of the *Cetiosaurus*, have been discovered in the oolite of the neighbourhood of the town of Buckingham, and form part of Dr. Buckland's museum.

Some vertebræ, an entosternal bone, a coracoid, scapula, and fragments of long bones, belonging apparently to the same skeleton, were disinterred from the middle oolite during the railway cuttings near Blisworth, and are preserved in the collection of Miss Baker at Northampton. The anterior transverse branch of the entosternum measures upwards of four feet across. The posterior caudal vertebræ, which, like those from Chipping Norton, measure five inches and a half in length, have a more hexagonal form, resembling, in this respect, the terminal caudal vertebræ of the *Cetiosaurus brevis* of the Wealden; they are, however, like the Chipping Norton specimens, of greater length.

In the museum of Professor Sedgwick, there is a caudal vertebra of the *Cetiosaurus* from the neighbourhood of Stratford-on-Avon. The size of the fossils hitherto obtained of the *Cetiosaurus medius*, especially the vertebræ, if calculated according to the numbers and proportions of those of the Crocodiles, gives a length of forty feet to this species.

Cetiosaurus longus.—In Professor Buckland's museum are preserved some fossil remains, principally vertebræ, of another enormous Saurian, which the form and texture of the vertebræ prove to belong to the genus *Cetiosaurus*, but which differ in the proportions of the vertebræ. One of these —a caudal vertebra—from the Portland stone at Garsington, near Oxford, measures in antero-posterior diameter of the centrum seven inches; in transverse diameter, seven inches nine lines; in vertical diameter of the centrum, six inches. Both articular extremities of the vertebra are slightly concave; the body is slightly compressed laterally; its middle part gives a subquadrate

* See Proceedings of the Geological Society, June 1841.

vertical section, with the angles slightly rounded; the expanded articular ends are subcircular. A fractured dorsal or lumbar vertebra, from the same locality, with transverse processes extending obliquely backwards from the upper part of the sides of the body, measures one foot across the nearly flat articular surface. The body of a caudal vertebra of the same species, from the Portland stone at Thame, measures seven inches four lines in antero-posterior diameter; six inches six lines in transverse diameter; and seven inches eight lines in vertical diameter. The under surface is concave lengthwise, and nearly flat from side to side; it is perforated by many large vascular canals. A third caudal vertebra is somewhat shorter in antero-posterior diameter, but exceeds the preceding in vertical diameter, which is eight inches. In all these vertebræ the neurapophyses are anchylosed to the centrum, and have a smaller antero-posterior extent at their base than the centrum, as in the preceding species of *Cetiosaurus*. In all the species the hæmapophyses are articulated to the interspaces of two vertebræ. To the *Cetiosaurus longus* is referable a vertebra, eight inches in length of body, and nine inches in transverse diameter, from the Yorkshire oolite at White Nab, which, together with some metatarsal bones, are deposited in the museum at Scarborough. No teeth, or fragments of jaws or cranium, have hitherto been discovered, which can, with certainty, be referred to any of the preceding species.

The names which I propose to give to these species refer to the relative length of their vertebræ, and from what we know of the constancy and regularity of this dimension in the back bone of individuals of the same species of Saurian, these specific names would, if we had the entire animals, be found to be as appropriate in reference to the relative length of their whole bodies.

At present the *Cetiosaurus brevis* is known to me only by specimens from the Wealden strata; the *Cetiosaurus medius* by fossils from the lower oolite, and the *Cetiosaurus longus* by a few vertebræ from both the upper and the lower oolite; but how far these species should actually characterize these divisions of the great oolitic system, will depend on the results of ulterior researches and a longer experience. It is certain, however, that we have in these remains ample proof of the existence, at that period of the earth's history which has been aptly termed the 'Age of Reptiles,' of another gigantic genus in addition to the *Pliosaurus*, *Poikilopleuron*, *Streptospondylus*, *Iguanodon*, *Megalosaurus* and *Hylæosaurus*.

The enormous *Cetiosauri*, some of which must have rivalled the modern whales in bulk, may be presumed to have been of strictly aquatic and most probably of marine habits, on the evidence of the sub-biconcave structure of the vertebræ, and of the coarse cancellous tissue of the long bones, which show no trace of medullary cavity. In the great expanse of the coracoid and pubic bones, as compared with the Teleosaurs and Crocodiles, the gigantic Saurians in question manifested their closer affinity to the *Enaliosauria*: their essential adherence to the Crocodilian type is marked by the form of the long bones of the extremities, especially the metatarsals; and, above all, by the toes being terminated by strong claws. The main organ of swimming is shown, by the strength and texture, and vertical compression of the posterior caudal vertebræ, to have been a broad vertical tail: and the webbed feet, probably, were used only partially in regulating the course of the swimmer, as in the puny Amblyrhynchus of the Gallipagos Islands, the sole known example of a Saurian of marine habits at the present period.

DINOSAURIANS.

This group, which includes at least three well-established genera of Saurians, is characterized by a large sacrum composed of five anchylosed ver-

tebræ of unusual construction, by the height and breadth and outward sculpturing of the neural arch of the dorsal vertebræ, by the twofold articulation of the ribs to the vertebræ, viz. at the anterior part of the spine by a head and tubercle, and along the rest of the trunk by a tubercle attached to the transverse process only; by broad and sometimes complicated coracoids and long and slender clavicles, whereby Crocodilian characters of the vertebral column are combined with a Lacertian type of the pectoral arch; the dental organs also exhibit the same transitional or annectent characters in a greater or less degree. The bones of the extremities are of large proportional size, for Saurians; they are provided with large medullary cavities, and with well developed and unusual processes, and are terminated by metacarpal, metatarsal and phalangeal bones, which, with the exception of the ungual phalanges, more or less resemble those of the heavy pachydermal Mammals, and attest, with the hollow long-bones, the terrestrial habits of the species.

The combination of such characters, some, as the sacral ones, altogether peculiar among Reptiles, others borrowed, as it were, from groups now distinct from each other, and all manifested by creatures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct tribe or sub-order of Saurian Reptiles, for which I would propose the name of *Dinosauria**.

Of this tribe the principal and best established genera are the *Megalosaurus*, the *Hylæosaurus*, and the *Iguanodon*; the gigantic Crocodile-lizards of the dry land, the peculiarities of the osteological structure of which distinguish them as clearly from the modern terrestrial and amphibious *Sauria*, as the opposite modifications for an aquatic life characterize the extinct *Enaliosauria*, or Marine Lizards.

Megalosaurus.

Of the gigantic Lacertians in question, the most remarkable are the *Megalosaurus*, *Iguanodon*, and *Hylæosaurus*, the worthy fruits of the laborious researches of Prof. Buckland and Dr. Mantell. With respect to the *Megalosaurus*, the great carnivorous terrestrial Lizard of the Wealden and Oolitic period, the lucid descriptions of its discoverer in his original Memoir and the 'Bridgewater Treatise,' and the judicious remarks of Cuvier on its natural affinities, leave little to be added, save the observations on the sacrum, to the present brief record of the strata and localities in which the remains of the *Megalosaurus* have been found.

The most complete collection of the bones of this genus has been derived from the oolite of Stonesfield, where the original specimens were first discovered. Dr. Buckland now possesses in his valuable collection portions of a lower jaw, the principal fragment containing a tooth fully developed, and the germs of several others; detached dorsal, caudal, and a series of five sacral vertebræ, ribs, two coracoid bones, a clavicle, humerus, radius, an ilium, an ischium, a femur, fibula, metacarpal and metatarsal bones.

These parts have not been discovered so associated together as to prove them to belong to the same animal; but the peculiar characters of some of the bones, which distinguish them from the other oviparous reptiles of the same strata, and the agreement in texture and proportionate size of the others, render their reference to the *Megalosaurus* highly probable.

* Gr. δεινὸς, fearfully great; σαύρος, a lizard. In the tabular arrangement of extinct Saurians founded by M. Herm. v. Meyer on the development of their organs of motion, the *Megalosaurus* and *Iguanodon* are grouped together in Section B, with the following character:—Saurians with locomotive extremities like those of the bulky terrestrial Mammals: "(Saurier mit Gliedmassen ähnlich denen der schweren Landsaügethiere)."—Palæologica, p. 201. No other grounds are assigned for their separation from other Saurians.

The essential characters of the most authentic of these remains prove the *Megalosaurus* to have been closely related to the Lacertian division of the Saurian order; but the teeth, the vertebræ, and some of the bones of the extremities, indicate its affinities to the Crocodilian group, and all these parts manifest more or less strongly the peculiar characters of its own remarkable family. In the instructive and characteristic portion of the lower jaw, the sockets, like the teeth, are compressed, and are separated by complete partitions; but they are so much wider than the teeth, as to suggest the existence of a greater proportion of ligamentous gum at the upper part of the alveolar tract in the recent animal than in the Crocodiles. "The outer rim of the jaw rises almost an inch above the inner rim, and forms a continuous lateral parapet, supporting the teeth externally; whilst the inner rim throws up a series of triangular plates of bone, forming a zigzag buttress along the interior of the alveoli. From the centre of each triangular plate, a bony septum crosses to the outer parapet, thus completing the alveolus*." There is a slight groove and ridge along the inner side of the sockets, and it is at this groove, at the interspace of each triangular plate, that the apices of the new teeth protrude. The teeth have compressed, conical, pointed crowns, with trenchant and serrate anterior and posterior edges. They appear straight when they first protrude, but are bent in the progress of growth; in the course of development the crown of the tooth is solidified, and the anterior margin at the base of the crown becomes smooth and convex. The smooth enamelled surface of the tooth presents fine polished wrinkles.

In all existing Lizards the teeth are anchylosed, either to the side of an outer alveolar parapet, according to the pleurodont type, or to its summit, according to the acrodont type. The double parapet, inclosing and concealing the germs and the bases of the full-grown teeth, is a remarkable approach in the present gigantic Dinosaur to the Crocodilian structure, the similarity in this respect no doubt resulting from a similar necessity in the carnivorous Megalosaur for a firm lodgment of the destructive maxillary weapons. The higher development of the outer alveolar parapet bespeaks the affinity of the *Megalosaurus* to the Lizards: in the form of the teeth it approaches nearest to the Varanian family, which at the present day includes the largest, and most carnivorous species of Lizard.

Vertebræ.—The Megalosaur deviates more decidedly from the existing Monitors and Lizards in its vertebral characters. These are afforded, at present, by the sacral, a few costal and caudal vertebræ. The articulating surfaces of the body of the vertebra are nearly flat or slightly concave, as in the cœlospondylian† Crocodiles. The non-articular surface is remarkably smooth and polished. The body is much contracted in the middle: the margins of the expanded articular extremities are thick and rounded off. The middle contracted part of the body is nearly cylindrical, being nipped in, as it were, by a more or less deep longitudinal fossa on each side, just below the base of the neural arch, but again slightly expands to support that part. The length of the base of the neurapophysis is nearly equal to that of the centrum: the suture is persistent, as in Crocodiles; its course is undulating, and it rises in the middle. The neurapophysis ascends and inclines outwards, to form, at a height above the centrum equal to three-fourths its vertical diameter, the margin of a broad platform of bone, from the sides of which the transverse processes are developed, and from the middle part the spinous process. A strong ridge or buttress of bone extends from the posterior angle of the base of the neurapophy-

* Transactions of the Geological Society, 2nd Series, vol. i. p. 395.

† I find this collective term convenient in application to those Crocodilians which have the vertebræ concave at both ends.

sis obliquely forwards to the under part of the transverse process; behind which ridge there is a deep depression, separating it from the posterior articular process. These processes are relatively smaller than in the *Iguanodon*, and do not project beyond the hinder end of the centrum. The spinal platform descends in a gentle curve from the posterior to the anterior oblique processes: the base of the strong and thick spinous process follows this curve along the middle line of the platform; its antero-posterior extent was $4\frac{1}{2}$ inches, in a vertebra having the centrum of the same length, with a vertical diameter of 4 inches, and measuring $7\frac{1}{2}$ inches from the under part of the centrum to the posterior part of the base of the spine.

Sacrum.—The sacrum of the *Megalosaurus* consists of five anchylosed vertebræ, and it is remarkable enough, considering how small a proportion of the recognizable bones of this rare reptile has been found, that the present characteristic part of the vertebral column of three different individuals should have been obtained: one sacrum, from Stonesfield, is in the museum of Dr. Buckland at Oxford; a second sacrum, from Dry Sandford, in the museum of the Geological Society; and a third sacrum, from the Wealden formation, in the British Museum.

I have studied each of these specimens with much attention, which a recognition of their remarkable structure has well repaid.

It would seem that Cuvier did not regard the five anchylosed vertebræ figured in Dr. Buckland's original memoir, as the sacrum of the *Megalosaurus*. They are briefly alluded to in the second and fourth editions of the 'Ossemens Fossiles,' and in the description of the Plate, in which Dr. Buckland's figure is reproduced as a 'Suite de cinq vertèbres de *Mégalosaurus*.' In truth the sacrum was not known to be represented, at that time, in any Saurian by more than two vertebræ, and therefore Dr. Buckland mentions this part in his original memoir as "five anchylosed joints of the vertebral column, including the two sacral and two others, which are probably referable to the lumbar and caudal vertebræ*." In contemplating this series of five anchylosed vertebræ, so new in Saurian anatomy, my attention was first arrested by the singular position of the foramina for the transmission of the nerves from the inclosed spinal marrow. These holes, which, in the plate illustrating Dr. Buckland's important memoir† are represented above the bodies of the three middle vertebræ, are natural, and accurately given: the smooth external surface of the side of the vertebra may be traced continuing uninterruptedly through these foramina, over the middle or nearly the middle of the centrum, into the surface of the spinal canal.

But the normal position of these foramina throughout the vertebral column in all other reptiles is at the interspace of two vertebræ, whence by French anatomists these holes are termed 'trous du conjugaison.' In the sacrum of the Oxford Megalosaur, however, it is evident that above the anchylosed intervertebral space a thick and strong imperforate mass of bone ascends to the base of the spinous process, leaving it to be conjectured either that the nerve had perforated the middle of the neurapophysis, or that these vertebral elements had undergone in this region of the spine a change in their usual relative position to the centrum. Previous researches into the composition and modifications of the vertebræ in the different classes of Vertebrata soon enabled me to recognize the peculiar condition and analogies of the five anchylosed vertebræ of the *Megalosaurus*; with a view to illustrate which I shall premise a few observations on the different relative positions which the peripheral vertebral elements may take in regard to the central part or body. The lateral vertebral elements, or ribs, the inferior laminæ or hæmapophyses,

* Geol. Trans., 2nd Series, vol. i. p. 395, pl. xlii. fig. 1. † Ibid.

the superior laminæ or neurapophyses, are all subject to such changes; but the neurapophyses are much more constant in their place of attachment than the others. In Mammalia the ribs for the most part are joined to the interspace of two centrums; in Reptiles each pair is attached to a single centrum. In Fishes, and the Mosasaur among Reptiles, the hæmapophyses depend, each pair from its proper centrum; in other Reptiles and Mammalia they are articulated to the interspace of two vertebræ, leaving a half-impression on each of the contiguous centrums. The neurapophyses present a degree of constancy in their relation to the body of the vertebra corresponding with the importance of their function. In Mammalia I know of no exception to the rule, that each neural arch is supported by a single centrum: in Birds no exception has hitherto been recorded; but among Reptiles the Cheloniæ* offer in those vertebræ, in which the expanded spinous processes contribute to form the carapace, the interesting modification analogous to those noticed in the lateral and inferior vertebral elements, viz. a shifting of the superior laminæ from the middle of the body to the interspace of two adjoining centrums; whereby that part of the spine subject to greatest pressure is more securely locked together, and a slight yielding or elastic property is superadded to the support of the neural arch.

The same modification is introduced into the long sacrum of birds; each neural arch is there supported by two contiguous vertebræ, the interspace of which is opposite the middle of the base of the arch above, and the nervous foramen is opposite the middle of each centrum. It is this structure, beautifully exemplified in the sacrum of the young Ostrich, which Creative Wisdom adopted to give due strength to the corresponding region of the spine of a gigantic Saurian species, whose mission in this planet had ended probably before that of the Ostrich had begun.

The anchylosed bodies of the sacral vertebræ of the Megalosaur retain the distinguishing characters which have been recognized in the dorsal and caudal vertebræ, in regard to the smooth and polished surface of their middle constricted part; the cylindrical, or nearly cylindrical transverse contour of this part below the lateral depression; their expanded, thickened and rounded articular margins, and also, though in a somewhat less degree, their relative length as compared with their breadth and height. The three middle sacrals are, however, somewhat shorter than the two terminal ones.

	In.	Lin.
Antero-posterior diameter of centrum of fifth sacral . . .	4	10
Vertical diameter of centrum of fifth sacral	4	1
Transverse diameter of centrum of fifth sacral	4	6
Vertical diameter of the middle of the body	2	6
Total height of fourth sacral vertebra	11	

The neural arches of the first three sacral vertebræ rest directly over the interspaces of the subjacent bodies; that of the fourth derives a greater proportion of its support from its proper centrum; and that of the fifth, which rests by its anterior extremity on a small proportion of the fourth centrum, is extended over nearly the whole length of its own centrum, so that in the caudal vertebræ the ordinary relations of the neural arch and centrum are again resumed. In the four first sacral vertebræ the base of the neural arch extends half way down the interspace of the bodies, and immediately developes from its outer part a strong and short transverse process (broken and rounded off in the fossil). From the base of this process the neurapophysis expands

* Cuvier describes the exceptional structure above alluded to in these Reptiles, and likewise cites the Chondropterygians; 'Leçons d'Anat. Comparée,' ed. 1836, tom. i. p. 213.

upward, forward and backward, is joined by vertical suture to similar expansions of the contiguous neurapophysis, and terminates above in a ridge of bone, at right angles to the suture; this ridge, with those of the other neurapophyses, extends longitudinally above the transverse processes the whole length of the sacrum, and forms the margin of the platform from which the spinous and accessory processes are developed. The platform is further supported by a compressed ridge of bone extended from the upper part of the transverse process, like a buttress, to the middle of the horizontal ridge. On each side of the buttress there is a depression, which is deepest in front. The spinous process is not developed, as in the dorsal vertebræ, immediately from the platform, but a shorter, vertical plate of bone, of nearly the same longitudinal extent as the true spine, is developed on each side of, and parallel with its base; the height of these accessory spines in the third sacral vertebra is three and a half inches. The true spinous process begins to expand longitudinally, and when near the summit of the accessory spines, is joined by vertical suture with the similarly expanded neighbouring spines, so that the sacrum is crowned by a strong continuous vertical longitudinal ridge of bone, at least along the four first vertebræ; the broad spine of the fifth being rounded off anteriorly, and separated by a narrow interspace from that of the fourth. Besides this modification of the spine, and the more normal position of the neural arch of the fifth anchylosed vertebra, the origin of the transverse process has been suddenly raised to the level of the spinal platform, and it is supported by two converging ridges of bone from the side of the neural arch below. The origin of the transverse processes of the first sacral is also placed higher than the three middle ones, in which the several peculiarities of structure above described are most strongly marked.

The specimens of sacrum of the *Megalosaurus* in the British Museum, and that of the Geological Society, present the same structure as that above described in the original specimen at Oxford. Part of the fifth sacral vertebra is wanting in the specimen from Dry Sandford. The rest are characterised by the same smooth and polished surface, rich brown colour, contraction of the middle of the body, its cylindrical form transversely, and the longitudinal fossa below the annular part. The length of this series is one foot six and a half inches; the second and third sacral vertebræ are rather shorter than the rest. The first sacral vertebra, which was not anchylosed to the last lumbar, gives the following dimensions:—

	In.	Lin.
Antero-posterior diameter of centrum	5	0
Vertical diameter of anterior articular end	4	0
Transverse diameter of anterior articular end . . .	4	6

The neural arch seems not to have been co-extensive in length with the centrum, but rests on its anterior three-fourths. A strong and short transverse process extends obliquely upwards and backwards from each side of the arch; the antero-posterior diameter of the base of this process is two inches, its vertical diameter one and a half inch. In the second sacral vertebra the neural arch has moved forward upon the interspace between the first and second sacral bodies, and developes from a lower part of its base a stronger, thicker and longer transverse process, directed outwards and forwards. The third neural arch has its base transferred directly over the interspace of the second and third centrums; the diameters of the base of its transverse processes are three inches and two and a half inches: they incline slightly backwards. The fourth neural arch descends lower down upon the interspace between the third and fourth centrums. The fifth neural arch, as in the Oxford specimen, extends a little way across the interspace between the fourth and fifth centrums,

but nearly resumes its ordinary place. The second and third sacral vertebræ are not so regularly convex below in the transverse direction, but their sides converge so as to give a slight indication of a broad obtuse ridge. The diameter of the spinal canal in the first and last sacral vertebræ is one inch.

The five vertebræ are not anchylosed in a straight line, but describe a gentle curve, with the concavity downwards; the series of transverse processes or sacral ribs, forms a curved line in the opposite direction, in consequence of their different positions. The summits of the anchylosed spines being truncated, describe a curve almost parallel with that of the under part of the vertebræ. The contour of the hinder part of the body of the present gigantic carnivorous lizard, doubtless raised high above the ground upon the long and strong hind-legs, must have been different from that of any existing Saurians. In these the relatively shorter hind-legs, being directed more or less obliquely outwards, do not raise the under surface of the abdomen from the ground; it is the greater share in the support of the trunk assigned to the hind-legs in the Megalosaur which made it requisite that, as in land mammals, a greater proportion of the spine should be anchylosed to transfer the superincumbent weight through the medium of the iliac bones upon the femora.

The femur, like the teeth and vertebræ, exhibits a mixture of the characters of the Monitor and the Crocodile. It is arched in two directions, being at first concave in front, and then behind. Its articular head is directed forwards, and has behind it a compressed and rather salient trochanter; it thickens towards the distal end, and there terminates in two unequal condyles. Near its upper third it has an expansion on both the inner and the outer side, like the one which is seen on the internal side of the femur in the Crocodile. The femur of the Monitor is less arched. The medullary canal is wide, which removes the Megalosaur from the Crocodiles, and indicates, as Dr. Buckland has well shown, its aptitude for a more terrestrial life.

The ribs, which from their colour, texture, and proximity of deposit, belong most probably to the *Megalosaurus*, present a double articulation with the vertebral column; the head is supported on a long and strong compressed neck, thickest at its under part; the tuberosity is large. One of the small cervical false ribs is preserved, the free extremity of which gradually tapers to a point.

The scapula is a thin, slightly-bent plate, of equal breadth, except where it is expanded and thickened towards the humeral end, but thinning off again towards the articular margin. The chief support of the humerus seems to have been afforded by a large and broad coracoid. The antero-posterior diameter of one of these bones, taken across the median, thin, slightly convex margin, is two feet three inches. The thickened process for the articulation with the scapula has a deep and narrow notch in front, and the deep and wide glenoid cavity for the humerus behind it; the posterior boundary of this cavity projects outwards in the form of an obtuse process. A short but strong process projects from the anterior part of the coracoid analogous to that which in the Varanian Monitors and most other Lizards abuts against the epicoracoids, and which bespeaks the existence of the epicoracoids in the *Megalosaurus*. The characteristic coracoid bone illustrates most unequivocally the affinities of the *Megalosaurus* to the Lacertian group of reptiles; but compared with the coracoid of a Varanian Monitor, four feet nine inches in length, it is sixteen times as large. This magnitude in a reptile, Cuvier justly observes, is quite appalling; for, other proportions being the same, the *Megalosaurus* must have exceeded seventy feet in length.

A long and slender bone, nearly two feet in length, most resembles the clavicle of certain lizards, especially, as Cuvier remarks, those of the great

Scincus. It is slightly arcuated longitudinally, subtrihedral in the middle, flattened and expanded at the two extremities. If it be really a clavicle, it forms as characteristic an indication of the Lacertian affinities of the *Megalosaurus* as the coracoid. According to the proportions of the clavicle in existing lizards, Cuvier observes that it bespeaks an animal nearly sixty feet in length.

A subcompressed, three-sided bone, flattened and slightly expanded at one end, thickened and more suddenly extended transversely at the opposite end, which formed part of a large cotyloid cavity, is most likely an ischium; its length is 18 inches; its breadth, at the middle of the shaft, 5 inches; at its articular end 9 inches, the thickness of this end being 4 inches. The ascending shaft of this bone is slightly twisted, convex and smooth on the outer side, flat and rough on the inner side.

Other bones, not improbably belonging to the *Megalosaurus*, are preserved in the British and Oxford Museums, and in the private collections of Messrs. Holmes and Saull; but further evidence of their Megalosaurian character must be obtained before a description of them can be profitably applied to the reconstruction of the skeleton of the present carnivorous Dinosaur.

A few words, however, may be added, touching the size of the *Megalosaurus*; for it appears to me that the calculations which assign to it a length of 60 and 70 feet are affected by the fallacy of concluding that the locomotive extremities bore the same proportion to, and share in the support of, the body, as they do in the small modern land lizards.

The most probable approximation to a true notion of the actual length of the *Megalosaurus*, is that which may be obtained by taking the length of the vertebræ as the basis. The antero-posterior dimension is the most constant which the vertebræ present throughout the spine: in most Crocodilian and Lacertian reptiles the cervical vertebræ are a little shorter than the dorsal; but these are of equal length, and the caudal vertebræ maintain the same length to very near the extremity of the tail.

As the dorsal vertebræ of the *Megalosaurus* agree, in the important character of the mode of articulation of the ribs, with the Crocodiles, it may be regarded as most probable that they also corresponded in their number. This does not exceed 14 in recent Crocodiles, nor 16 in any of the known extinct species; taking, then, the latter number, and adding to it 7, the usual number of the cervical vertebræ in Crocodiles, we may allow the *Megalosaurus* 23 vertebræ of the trunk.

The length of the body of a large dorsal vertebra of the *Megalosaurus* in the British Museum is $4\frac{1}{2}$ inches: from the analogy of the *Iguanodon*, in which several dorsal vertebræ have been discovered in their natural juxtaposition, it is probable that the thickness of the intervertebral substance did not exceed one-third of an inch: but if we multiply 23 by 5, not allowing for the probable shortness of the cervical vertebræ, we only then attain a length of 9 feet 7 inches. If, however, setting aside the analogy of the *Megalosaurus* to the Crocodiles in the structure of the vertebræ, we take that species of Lacertian which it most resembles in the structure of the teeth, and found our calculation on the number of vertebræ of the trunk in such lizard, then, the great carnivorous Varanian Monitor of Java having 27 vertebræ of the trunk, we do not, even calculating the same number of vertebræ to have occupied each a space of five inches in the *Megalosaurus*, obtain a length of trunk exceeding 11 feet 3 inches.

I should consider the first calculation, or about 10 feet, to have been the most probable natural length.

To this we must add 1 foot 10 inches for the known length of the sacrum. Thus 12 feet will be a fair or even a liberal allowance of length from the

occiput to the beginning of the tail. In Crocodiles the skull equals about 12 dorsal vertebræ in length. In the Java Monitor the proportion of the head is less. In the Iguana the cranium does not exceed 6 dorsal vertebræ in length.

We may consider therefore 5 feet, taking the Crocodile as the term of comparison, as probably not below the length of the head of the Megalosaur. With regard to the tail, this includes between 36 and 38 vertebræ in Crocodilians, but varies from 30 to 115 in the small existing Lacertians, in many of which it is a prehensile organ, aiding them in climbing and other actions suitable to their size. It is very improbable that the tail should have presented such unusual proportions in the great Saurian under consideration, and indeed very few caudal vertebræ of the Megalosaur have been as yet discovered, and none exceeding 4 inches in length. Allowing the Megalosaur to have had the same number of vertebræ as the Crocodile, and multiplying this number 36 by $4\frac{1}{2}$, a length of 12 feet 6 inches is thus obtained for the tail. A calculation on this basis thus gives, in round numbers,

Length of head	5 feet.
Length of trunk, with sacrum	12 —
Length of tail	13 —
Total length of the *Megalosaurus*	30 —

Upon this mode of obtaining an idea of the bulk of the present extinct reptile I am disposed to place the greatest reliance, and conceive that any error in it is more likely to be on the side of exaggeration than of curtailment. From the size and form of the ribs it is evident that the trunk was broader and deeper in proportion than in modern Saurians, and it was doubtless raised from the ground upon extremities proportionally larger and especially longer, so that the general aspect of the living Megalosaur must have proportionally resembled that of the large terrestrial quadrupeds of the Mammalian class which now tread the earth, and the place of which seems to have been supplied in the oolitic ages by the great reptiles of the extinct Dinosaurian order.

Besides the Stonesfield slate, the remains of the *Megalosaurus* have been found in the Bath oolite immediately below that slate, and in the cornbrash above it. The other formation in which the remains of the Megalosaur occur, next in importance to the Stonesfield slate, is the Wealden strata. Dr. Mantell has discovered in the ferruginous clay of the Forest of Tilgate a fine vertebra, and a portion of the femur of the *Megalosaurus*, 22 inches in circumference. Many teeth have been discovered altogether of the same form as those found by Dr. Buckland. Some fragments of the metacarpus and metatarsus from this locality, were thicker than those of a large hippopotamus. Mr. Holmes, surgeon at Horsham, possesses a good caudal vertebra, and some other parts of the *Megalosaurus* from the ferruginous sand near Cuckfield in Sussex. Remains of the *Megalosaurus* occur in the Purbeck limestone at Swanage Bay. In some of the private collections in the town of Malton, Yorkshire, are teeth, unquestionably belonging to the same species as the Stonesfield *Megalosaurus*, from the oolite in the neighbourhood of that town.

The tooth from the New Red Sandstone of Warwick figured in the Memoir by Messrs. Murchison and Strickland*, and referred to the *Megalosaurus*, belongs to another genus of Lacertian, more nearly allied to the *Palæosaurus* of the Bristol conglomerate.

* Geol. Trans., 2nd Series, vol. v. pl. xxix. fig. 7.

Hylæosaurus.

A second well-marked genus of Dinosaurian Reptiles is founded upon a large portion of the skeleton of the reptile to which the name at the head of this section has been applied by its discoverer, Dr. Mantell.

In assigning to this genus its present place in the Dinosaurian order, I have been guided by the structure of the vertebral column, especially the sacrum, and by the following considerations. The distinct alveoli in the jaws of the *Megalosaurus*, and the resemblance of its teeth to those of two extinct Crocodilians, viz. the Argenton species and the *Suchosaurus*, seemed to claim for that great carnivorous Dinosaur the next place to the Crocodilian order, among which the *Streptospondylus*, as has been shown, seemed to make the closest approximation to the *Megalosaurus*, in the great height, complexity and strength of the neural arch of the vertebræ. In the present genus, which there is good reason for believing to have resembled the Lizards more than the Crocodiles in its dental characters, an affinity to the Loricate Sauria is manifested not only by the structure of the vertebræ and ribs common to it with other Dinosaurs, but likewise by the presence of dermal bones, or scutes, with which the external surface was studded.

The *Hylæosaurus* has not been made known like the *Megalosaurus*, from detached parts of the skeleton successively discovered and analogically recomposed, but was at once brought into the domain of Palæontology by the discovery of the following parts of the skeleton in almost natural juxtaposition: viz. the anterior part of the trunk, including ten of the anterior vertebræ in succession, supporting a small fragment of the base of the skull; the two coracoids, the coracoid extremities of both scapulæ, detached vertebræ, several ribs more or less complete, and some remarkable parts of the dermal skeleton, including, apparently, enormous vertical plates or spines, arranged, as is supposed, in the form of a median dorsal ridge or crest of singular dimensions.

In the fragment of the cranium may be distinguished the pterygoid elements of the sphenoid bone, the inner margins of which touch anteriorly and then recede as they pass backwards, leaving a heart-shaped posterior nasal aperture, the apex of which is turned forwards. The breadth of this aperture is 1 inch 3 lines: its posterior position gives another character, by which the present Dinosaur, and probably the larger genera of the same order, resembled the Crocodiles more than the Lizards.

The bodies of the vertebræ are shorter in proportion to their breadth than in the *Megalosaurus* or *Iguanodon*. They have not so smooth and polished a surface as in the *Megalosaurus*, nor are they so contracted in the middle, or so regularly rounded below from side to side; a few of the anterior vertebræ are somewhat flattened below, so as to present an obscurely quadrate figure; most of the anterior dorsals are more compressed and keel-shaped below: the sacral and caudal vertebræ are longitudinally sulcated at their under surface.

The structure of the atlas and axis cannot be discerned in the Mantellian specimen; the second (conspicuous) cervical vertebra has its sides subcompressed, its under surface flattened, and the anterior part of the slight angular ridges separating it from the concave lateral surfaces, are produced anteriorly into two feebly-marked tubercles. The inferior transverse processes are developed from each side of the anterior part of the body of the vertebra; they are subcircular, very slightly prominent, about 7 lines in diameter.

In the fourth (conspicuous) vertebra, a large proportion, but not the whole, of a costigerous transverse process is developed from each side of the anterior

part of the body, with the costal surface directed obliquely outwards and forwards. There is a small costal surface at the side of the expanded posterior extremity of the same vertebra, against which a part of the head of the fourth rib abuts; that and three of the succeeding ribs having their heads applied over the interspace of two contiguous vertebræ, as nearly throughout the thoracic region in Mammalia. The lateral compression of the centrum increases in the sixth and seventh (conspicuous) vertebræ, in which the under surface forms an obtuse ridge; in the eighth vertebra this surface is broader. In none of these vertebræ is a process developed from the under surface as in the hinder cervical and anterior dorsal vertebræ of the Crocodiles.

The most striking character of the vertebræ of the *Hylæosaurus* is the great development of the neural arch and its processes. The anterior articular processes extend (in the anterior dorsal and cervical vertebræ) over half the centrum next in front, and a broad upper transverse process is developed from the side of the neurapophysis and along its anterior continuation: this transverse process extends horizontally outwards, is notched anteriorly, and contracts to an obtuse point against which the tubercle of the rib articulates: the transverse processes are flat transversely, slightly concave lengthwise, and smooth below: they increase in length and strength as the vertebræ extend along the trunk; and the ribs, which they contribute to support, exhibit a still more rapid increase: the ribs present, as in the other Dinosaurs and Crocodiles, a bifurcated vertebral end for the double articulation above described*. The neck and head of the rib corresponding with the seventh conspicuous vertebra is 2 inches 2 lines in length; the tubercle, or upper head, is 10 lines long; the breadth of the rib at the point of bifurcation is 1 inch 1 line. The neck of the eighth rib has the same length as that of the seventh, but is twice as thick and strong; the tubercle is broader but shorter. Beyond the tubercle the shaft of the rib is bent at right angles with the neck. This soon begins to shorten, and the shaft of the rib to lengthen, until it becomes attached solely to the transverse process.

In the dorsal vertebræ the body increases in all its proportions, excepting its length. The lateral compression now manifests itself at the upper part of the centrum just below the neurapophysial suture; the under surface of the posterior dorsal and lumbar vertebræ is convex transversely, but in a less degree than in the *Megalosaurus*, and in some, it is obscurely carinated. The external surface at the middle contracted part of the vertebra is moderately smooth, but the minute striæ give it a somewhat silky lustre; it is longitudinally but irregularly ridged and grooved near the articular ends. These are both slightly concave at the centre, more slightly convex near the circumference. The difference between the vertebræ of the Hylæosaur and the biconcave Crocodilian vertebræ is chiefly manifested in the development of the neural arch. The modification of this part in the cervical vertebræ has already been mentioned. In the dorsal vertebræ each neurapophysis rises vertically, contracting in the axis of the vertebra, expanding transversely or outwardly, until it has attained a height equal to that of the centrum; there it expands into a broad and flat platform, from the middle line of which the broad spine is developed. A vertically compressed but strong transverse pro-

* Dr. Mantell, in his Memoir on the Tilgate Saurians, Philos. Transactions, Part ii. for 1841, which I received while this Report was going through the press, says that "the bilobed head and the great external expansion of the arch of the rib in all probability bears a relation to the enormous development of the dermal spines," p. 143. But this is precisely the modification of the skeleton in which the *Hylæosaurus* differs most from the existing Saurians which possess such spines, as the *Cyclura*, and in which it most resembles the *Iguanodon* and *Megalosaurus*.

cess is developed from the side of the neurapophysis, and is supported by a pyramidal underprop, extending upwards and outwards from the anchylosed base of the neurapophysis. There is a large, deep and smooth depression on each side of the base of the transverse process. The anterior surface of the neural arch, above the anterior oblique processes, is traversed by a vertical ridge, on each side of which there is a shallow depression*. The spinous process is of unusual thickness, its transverse breadth at the base measures 1 inch: this modification may probably relate to the support of great dermal spines. The spinal canal in the dorsal vertebræ is cylindrical, and expanded at both extremities; its diameter at the middle is 7 lines, at the expanded outlets 10 lines, in a posterior dorsal or lumbar vertebra. Here the bases of the neurapophyses begin to shorten, and leave a small proportion of the upper surface of the centrum uncovered at both ends, chiefly at the posterior end.

The following are dimensions taken from three of the vertebræ of the *Hylæosaurus*:—

	Second conspicuous cervical.		Fourth conspicuous cervical.		Middle dorsal.	
	In.	Lin.	In.	Lin.	In.	Lin.
Antero-posterior diameter of body .	1	10	2	2	2	9
Vertical diameter of its articular end	0	0	1	6	2	6
Transverse diameter of its articular end	2	0	2	2	3	0
Transverse diameter of middle of body	0	0	0	0	2	0

The differences between the vertebræ of the *Hylæosaurus* and *Megalosaurus* have been already pointed out, and are further shown in the admeasurements given above: the vertebræ of the *Hylæosaurus* differ from those of the *Iguanodon* in their greater transverse diameter, and in the breadth of their under part; those of the *Iguanodon* are flatter vertically along their whole sides, which converge to a narrower ridge at the under part. The vertebræ of the *Hylæosaurus* differ from those of the *Streptospondylus* in the sub-biconcave character of the articular ends of the centrum, and in its comparative shortness and thickness: the separated neural arch might be distinguished from that of the *Streptospondylus* by the simplicity of the supporting buttress of the transverse process; and, although equal in height, yet it is superior in the expansion and strength of the platform and spinous process.

Sacrum.—There is a portion of a sacrum of a small or young Dinosaur (No. $\frac{484}{2484}$, Mantellian Collection), which, in the form and proportions of the bodies of the vertebræ, most resembles the present genus, and cannot be referred to *Megalosaurus* or *Iguanodon*. It includes two entire and parts of two other vertebral bodies, anchylosed together, and to the bases of the neurapophyses; which, as in the *Megalosaurus*, are transferred to the upper and lateral parts of the interspaces of the subjacent bodies. These are moderately, but regularly, contracted in the middle and chiefly laterally, being more flattened below, where likewise each is traversed by a longitudinal sulcus. At the middle of each lateral concavity there is a vascular perforation. I am uncertain which is the anterior part of this interesting series; but, by the analogy of the *Megalosaurus*, conclude that vertebra which supports the greatest proportion of its neural arch, to be posterior to the adjoining one which supports the remaining small proportion. On this basis also I assume that the anterior sacral vertebra is deficient, if we may allow five to the Hylæosaur as to the other Dinosaurs.

The second sacral vertebra, then, is here broken across the middle of the

* This description is taken from Nos. 2586 and 2125, parts of the same vertebra in the Mantellian Collection.

body, exposing its solid minutely cellular central structure: its neural arch is too mutilated for profitable description: its base rests nearly equally on the second and third sacral bodies. The third neural arch, which exhibits a similar relative position, has its base extended half way down the interspace; its strong transverse process extends outwards and forwards, and is at first contracted, then expands both transversely and vertically, most so in the latter direction, and is twisted obliquely, so that the lower end is directed downwards and forwards, and the upper and thicker end is bent obliquely backwards, until it meets and becomes anchylosed to the anterior production of the transverse process of the next vertebra behind: an elliptical space is thus produced, the axis of which is nearly vertical, and into this space the neural canal opens; the nerve being transmitted over the middle of the body of the vertebra, as in the sacrum of the *Megalosaurus*.

The upper and inner part of the base of the broad, oblique transverse process, or sacral rib, abuts against the base of the spinous process. There is no appearance of accessory spines, such as the sacrum of the *Megalosaurus* is complicated with.

The following are admeasurements of the present portion of the sacrum of the *Hylæosaurus*:—

	In.	Lin.
Length of the body of the third vertebra	2	0
Breadth of its articular end	2	0
Breadth of its middle part	1	4
Breadth of its inferior groove	0	4
Length of the transverse process	1	10
Antero-posterior diameter of the middle of process	0	4
Vertical diameter of base of process	1	6
Vertical diameter of expanded extremity	3	0
From the lower part of centrum to the origin of the spinous process	2	6

The spines appear to be anchylosed into a continuous ridge.

The anterior surface of the transverse process appears undulated by wide shallow depressions and intervening elevations.

Caudal vertebræ.—A proportion of the tail, to the extent of nearly six feet, and including about twenty-six vertebræ, discovered in a quarry in Tilgate Forest in the year 1837, is preserved in the Mantellian Collection. The transverse processes present almost Crocodilian proportions, in regard to their length, at the anterior part of this series, and may be discerned, though diminished to mere rudiments, in the small terminal vertebræ of the series. In the most perfect of the anterior vertebræ they are compressed vertically, but with convex, not flattened sides, and rounded edges, presenting an elliptical transverse section, and preserving the same breadth to their truncated extremity: they extend outwards, and are slightly bent forwards: the breadth of this vertebra between the extremities of the transverse processes is 11 inches. The neurapophysis is curved forwards from the base of the transverse process to form the anterior oblique process: its length from the extremity of this process to that of the posterior one is $3\frac{1}{2}$ inches. The neurapophysis presents a simple convex external surface to the base of the spine: the antero-posterior extent of this process is two inches. The chevron bones are from four to five inches in length near the base of the tail; they may be distinguished, like the transverse processes, by their convex external surface; their base is open, not confluent as in the *Iguanodon*, and articulated to two distinct tubercles. Between these tubercles, which are placed at each end of the under surface of the centrum, there is a longitudinal sulcus. The transverse processes soon lose the slight anterior curve, stand straight out, decrease in

length, and descend from the neurapophysis to the centrum as the vertebræ approach the end of the tail.

The chevron bones also decrease in length, but they expand in the antero-posterior direction at their unattached and dependent extremity, which is defined by a slight convex outline. The following admeasurements give the rate of decrease in length in the caudal vertebræ, taken at intervals of six joints:—

	In.	Lines.
Length of body of presumed 8th caudal	2	6
Length of body of presumed 14th caudal	2	4
Length of body of presumed 20th caudal	2	2

The sides of the slender posterior vertebræ are distinguished by a slight median expansion below the base of the rudimental transverse process, so that the surface, instead of being gently concave lengthwise, undulates by virtue of the middle elevation. I have not met with this character in the corresponding vertebræ of other Saurians. In the vertical direction the sides of the centrum in the posterior caudals converge at almost a right angle to the inferior groove. The greater breadth of the centrum, in proportion to its height, may still be discerned in the terminal caudal vertebræ: thus in the centrum 2 inches 2 lines long, the breadth was 1 inch 10 lines, and the height only 1 inch 3 lines.

Dermal scutes.—Unequivocal evidence that a dermal skeleton, analogous to that in the recent Crocodiles, was developed in the *Hylæosaurus*, was afforded by the discovery of bony scutes in the mass of vegetable matter removed in clearing the portion of the skeleton first described. Some of these detached bony plates still adhere to the caudal vertebræ, and may be observed to decrease in size as they approach the end of the tail. From their form, which is elliptical or circular, and from the absence of any surface indicating the overlapping of an adjoining scute, it may be inferred, that the bony plates in question studded in an unconnected order the skin of the Hylæosaur. The diameter of the largest of these scutes does not exceed three inches; the smallest present a diameter of one inch. They are flat on the under surface, convex with the summit developed into a tubercle in the smaller specimens, but which is less prominent in the larger ones: the outer surface is studded all over by very small tubercles: the inner surface presents the fine decussating straight lines, already noticed in the scutes of the *Goniopholis*.

By the kindness of Dr. Mantell, I have been favoured with the means of submitting the structure of a dermal scute to microscopical examination.

The medullary canals, which are stained brown, as if with the hematosine of the old reptile, differ from those of ordinary bone in the paucity or absence of concentric layers. They are situated in the interspaces of straight opake decussated filaments, which frequently seem to be cut short off close to the medullary canals. Very fine lines may be observed to radiate from some of the medullary canals: irregularly shaped, oblong and angular radiated cells are scattered through most parts of the osseous tissue, but they present less uniformity of size than do the Purkinjian cells in ordinary bone. The most striking characteristics of the dermal bone are the long straight spicular fibres which traverse it, and decussate each other in all directions, representing, as it seems, the ossified ligamentous fibres of the original corium.

Dermal spines?—On the left side of the thorax, partly overlying the left scapula and vertebral ribs, in the large slab of stone containing the anterior part of the skeleton, there are some large elongated, flattened pointed plates of bone, three of which seem to follow each other in natural succession. The length of the first of these plates is seventeen inches, the breadth of the base five inches, equal to the antero-posterior diameter of two vertebræ: they de-

crease somewhat rapidly in length, the second being fourteen inches long and the third eleven inches long; but slightly increase in breadth.

These remarkable bones are regarded by Dr. Mantell* as having formed part of a serrated fringe extended along the back of the animal, analogous to that of the *Cyclura* Lizard. This ingenious suggestion carries with it so high a degree of probability, that I had not thought of comparing the bones in question with any other part of the skeleton, until my attention was arrested by observing a want of symmetry in the form of the most perfect of them. They are nearly flat, but along the middle present a slight degree of concavity towards the observer, which, however, may be paralleled by a similar concavity on the opposite side buried in the stone; but the anterior or convex margin inclines from the middle line towards the concave side. With regard to their relative position to the rest of the skeleton, it must be observed that the ventral surface of this is exposed; so that the under parts of the bodies of the vertebræ are towards the observer, and their spines imbedded in the matrix. The coracoid and scapular arch are placed, as might be expected in a skeleton little disturbed and lying on its back, with their under surfaces towards the observer, and covering, like a buckler, a portion of the vertebræ and ribs. In this position we might look for a portion of the apparatus of the sternal or abdominal ribs, in the hope of discerning the modifications of these variable parts which might characterize a genus differing in many peculiarities from other known Saurians. Now it is with the apparatus of abdominal ribs, which present such a diversity of characters in other Saurians, that it may be useful to compare the long flattened bones in question, as well as with the supporting bones of a dorsal crest, in the event of a future discovery of a skeleton or portion of skeleton of the *Hylæosaurus* including these bones. The objection to their being abdominal ribs, which may be founded on their great relative breadth as compared with those ribs in other Saurians, and especially with the vertebral ribs of the *Hylæosaurus* itself, deserves due consideration; but the same objection applies to the bones in question as compared with the superadded spines in the Lizard with a dorsal fringe, or with the spines of the vertebræ themselves in the *Hylæosaurus*. For the dorsal dermal spines in the *Cyclura* correspond in number with the spines of the vertebræ which support them, while the base of each of the hypothetical dermal spines of the Hylæosaur extends over more than two vertebræ.

In the *Monotremata* (*Ornithorhynchus* and *Echidna*) the abdominal ribs are as much broader than the vertebral ribs as they would be in the *Hylæosaurus*, on the costal hypothesis of the detached bony plates here suggested; and, after the close repetition, in the *Ichthyosaurus*, of another of the remarkable deviations in those aberrant Mammals from the osteological type of their class, viz. in the structure of their sternal and scapular arch, the reappearance of the monotrematous modification of the sternal ribs in the present extinct reptile would not be surprising. The want of symmetry and the difference of size and form, above alluded to, in the four succeeding spine-shaped plates, agree better with the costal than the spinous hypothesis.

Whether the bones in question be dorsal spines or abdominal ribs, they have evidently been displaced from their natural position in the partial disarticulation of the entire skeleton prior to its immersion in the mud that has been subsequently hardened around it; but the degree of displacement has not been greater in the one case than in the other.

In offering, with due diffidence, a choice of opinions respecting the nature of these singular bones, I have been actuated solely with the view of accelerating the acquisition of the true one, which, it is obvious, will be more likely

* Geology of South-east of England, p. 323. Wonders of Geology, vol. i. p. 402.

to be attained by the choice being present to the mind of subsequent fortunate discoverers of these remains of the *Hylæosaurus*, than if they were solely preoccupied by the hypothesis of the dorsal fringe. For example, it may lead to more careful noting of the constancy or otherwise of the unsymmetrical inclination of the convex margin of the spine, and whether they form, or are disposed in, pairs; which, on the costal hypothesis, may be expected, in the event of another skeleton being discovered.

Bones of the Extremities.

Scapular arch.—The scapula of the *Hylæosaurus** is longer and narrower than in the Monitors and Iguanas, adhering in this respect to the Crocodilian type, but most resembling in the shape of its blade or body, that of the genus *Scincus*. It differs, however, from the scapulæ of all known reptiles, and indicates an approach to the Mammalian type, by the production of a strong obtuse acromial ridge, separated by a deep and wide groove from the humeral and coracoid articular surfaces. The blade of the scapula is long, flattened, slightly convex on the inner and proportionally concave on the outer surface: the anterior margin is convex, the posterior one concave; the upper extremity or base truncate, slightly convex, with the posterior angle a little produced, the anterior angle rounded off. On the outer side of the scapula two broad convex ridges descend and converge to form the beginning of a thick and strong spine, at fourteen inches distance from the base; this then expands into the thick acromial ridge, which extends transversely, and is continued forwards as a long subprismatic process from the anterior angle of the head of the scapula. This process, which appears likewise to be present in the scapula of the *Iguanodon*, perhaps also in the *Megalosaurus*, is broken off in the present specimen about four inches from the neck of the scapula, with which it forms a right angle. The acromion is perforated at the base of its anterior prolongation by a foramen analogous to the supraspinal one in the scapula of the Edentate Mammalia. Besides the scapulæ preserved in the connected part of the skeleton, there is, in the Mantellian Museum, a nearly entire and detached scapula of larger size, discovered, in connexion with many other bones of the skeleton, in a layer of blue clay near Bolney in Sussex, and indicating the connected part of the skeleton first discovered in 1832 to have belonged to an immature individual. The dimensions of this scapula are as follows:—

	In.	Lines.
Length of the scapula	18	0
Breadth of its base	8	0
Breadth of its neck	3	9
Thickness of its base	1	0
Thickness of its neck	2	6
Breadth of subacromial groove	2	0
Breadth of humeral articulation	4	0
Breadth of coracoid articulation	2	6

The *coracoids* present a much more simple form than in the *Megalosaurus*, and resemble those of the Scink and Chameleon, thus deviating in their great breadth, like the coracoids of the Enaliosaurs, from the Crocodilian type. In the portion of the skeleton the right coracoid is slightly bent out of place and thrust under the left one; and there is no trace of a sternal or entosternal bone in their interspace. The median margin of the coracoid describes an unin-

* I have been favoured by Dr. Mantell with a drawing of the scapula figured by him in his recent Memoir on the *Hylæosaurus*, Phil. Trans., 1841, pl. x. fig. 10. The description above given of this, as of all the other Tilgate Saurians in the present Report, is taken from the original specimens in the British Museum, and other depositories of the Wealden fossils.

terrupted and full convex curve commencing at the angle dividing it from the scapular articular surface; but it is separated by a concavity or emargination from the articular surface for the humerus. It is perforated by a moderate sized elliptical canal, about two inches from the humeral articulation, and in this respect resembles the same bone in the Iguana, Monitors and Lizards, and differs from the Scinks and Chameleons. The antero-posterior extent of the coracoid in the connected portion of skeleton is eight inches; its transverse diameter five inches.

A humerus, and a phalangeal bone found with the scapula, near Bolney, are figured by Dr. Mantell in the Memoir of 1841.

Teeth of the Hylæosaur?—With regard to the *Hylæosaurus* Dr. Mantell observes, in his latest geological work, "the teeth are unknown; but in the quarries where the bones of that reptile were discovered, I have found teeth of a very peculiar form, which appear to have belonged to a reptile, and are entirely distinct from those of the *Megalosaurus*, *Iguanodon*, Crocodile and *Plesiosaurus*, whose remains occur in the Tilgate strata*." The form and structure of these teeth, which will be presently described, deviate too much from those of the Crocodilian family to make at all probable a reference of them to the genera Poikilopleuron, Streptospondylus, or Cetiosaur, which are much more closely allied to the Crocodilians than is the Hylæosaur. In the 'Geology of the South-east of England,' Dr. Mantell attributes these teeth, on the authority of M. Boué, to the *Cylindricodon*, a name by which Dr. Jäger distinguishes one of the species of his genus '*Phytosaurus*.' I have been favoured by Dr. Jäger with one of the bodies supposed to be the teeth of the *Cylindricodon* of the Wirtemberg Keuper, but it is merely the cast of a cylindrical cavity, consisting entirely of that mineral substance, without a trace of dental structure. The difference of form between the Wealden teeth now under consideration, and those on which the *Phytosaurus cylindricodon* of Jäger was founded, is pointed out in detail in my Odontography, and has been likewise appreciated by the estimable Palæontologist, M. Fischer de Waldheim, by whom their resemblance to certain Saurian teeth from the Ural Mountains, belonging to the genus *Rhopalodon*†, is indicated. From these teeth, however, the presumed Hylæosaurian teeth differ in having thick and flat instead of serrated coronal margins. The following is Dr. Mantell's original description of the teeth in question:—

"These teeth are about an inch and a quarter in length, and commence with a subcylindrical shank, which gradually enlarges into a kind of shoulder, terminating in an obtuse angular apex, the margins of which are more or less worn, as if the teeth had been placed alternately so as to meet at their edges, as in pl. ii. fig. 3. They are obscurely striated longitudinally, and have a thick coat of enamel: the crown of the tooth is solid, but the shank is more or less hollow. All the specimens appear as if they had been broken off close to the jaw; but they may have been separated by necrosis occasioned by the pressure of the supplementary teeth‡."

The following is the result of a microscopical examination of these teeth. The tooth consists of a body of dentine covered by a thick coating of clear structureless enamel, and surrounding a small central column of true bone, consisting of the ossified remains of the pulp, which presents the usual characters of the texture of the bone in the higher reptiles. The dentine differs, like that of existing Lacertians, from the dentine of the *Iguanodon* in the entire absence of the numerous medullary canals which form so striking a cha-

* Wonders of Geology, vol. i. p. 403.

† Lettre sur le *Rhopalodon*, Moscow, 8vo, 1841.

‡ Geology of the South-east of England, p. 293.

racteristic of the more gigantic Wealden reptile. The main calcigerous tubes are characterized by the slight degree of their primary inflections; they are continued in an unusually direct course from the pulp-cavity to the outer surface of the dentine, at nearly right angles with that surface, but slightly inclined towards the expanded summit of the tooth. They are chiefly remarkable for the large relative size of their secondary branches, which diverge from the trunks in irregular and broken curves, the concavity being always towards the pulp-cavity. In most parts of the tooth, the number of these branches obscures even the thinnest sections.

The ossified pulp exhibits the parallel concentric layers of the ossified matter surrounding slender medullary canals, and interspersed with irregular elliptical radiated cells.

Jaw of the Hylæosaurus?—No. $\frac{422}{2422}$, in the Mantellian Collection, is a portion of the right ramus of the lower jaw, with characters distinguishing it from that of any other known Saurian; as, for example, its degree of curvature, indicating the lower jaw to have been bent down in an unusual degree, and the remarkable inequality of its external surface. This fragment is about three inches long, one inch seven lines deep at the hind part, and one inch five lines deep at the fore-part; flattened and smooth at the inner side, but having the outer side raised by the termination of a strong angular ridge at its lower and hinder part, and by a rough convex longitudinal ridge extending along its upper part; the surface of the jaw being concave above and below this ridge. The lower margin is thick and convex; the upper one is formed by a regular series of pretty close-set sockets, with the internal alveolar wall broken away, displaying their partitions; but with the outer wall entire, thin and slightly crenate at its upper margin.

At the hind part of this fragment the anterior extremity of the opercular piece is preserved; the rest is formed exclusively by the dentary piece: the area of the wide conical cavity in the interior of the jaw is exposed at the back part of the fragment; its apical termination is near the fore part. A succession of large vascular canals open obliquely forwards in the concavity above the upper oblique longitudinal ridge. The whole of the outer surface is minutely ridged and punctate.

The depth of the sockets bears a smaller proportion to that of the jaw than in modern Lacertians or Crocodiles, being about one-fourth of that depth: the partitions of the sockets, which are very regular in their breadth and depth, though they are more prominent than in the pleurodont Lizards, yet exhibit a fractured margin; there is no trace of a smooth natural surface of the bone in the interspace of the sockets; and at the part where the inner wall has been least mutilated, it nearly completes the socket and incloses the long and slender fang of the tooth. Whence, I conclude, that the entire jaw of the extinct reptile would have exhibited a series of true sockets, not depressions merely, as in the present mutilated fragment, and that it would have agreed with the *Megalosaurus* in presenting the thecodont mode of attachment of the teeth.

The crowns of all the teeth are broken off; the small sockets of reserve, exposed at the inner side of the base of the old sockets, do not contain any evidence of the species to which this fossil has belonged. In the absence of this characteristic part of the tooth, an element in guiding our choice between the *Iguanodon* and *Hylæosaurus* is given by the breadth of the interspaces of the sockets; these must bear relation to the breadth of the crowns of the teeth, if we suppose that they were in contact throughout the series, as in Lacertians. Now the teeth of the *Iguanodon*, and those which I have referred to the *Hylæosaurus*, differ in a marked degree in the breadth of the

crown. The complicated and expanded crown of the Iguanodon's tooth is supported on a narrower stem; and the stems or fangs, if the crowns were in contact without overlapping, must have been separated by interspaces of proportional breadth, viz. twice their own breadth; but the thickness of the crown of the tooth of the *Iguanodon* renders it very unlikely that they did overlap each other. Now the crowns of the teeth of the Hylæosaur are expanded to such an extent, as, if in contact to require an interspace of the fangs, not broader than the fangs themselves; and the interspaces of the fangs in the fragment of jaw under consideration correspond with crowns of this breadth. The fangs of the teeth in the *Iguanodon* are conical, and more or less angular; in the teeth presumed to belong to the Hylæosaur the fangs are cylindrical; the sockets in the present fragment correspond with the latter form.

In my Odontography*, I adopted the opinion of Dr. Mantell† respecting the present fossil; but subsequent examination and consideration of its characters have led me to a different conclusion. It might, nevertheless, be urged that the teeth of the young *Iguanodon* may exhibit such modifications as would affect the validity of the objections here offered; but these, I think, establish the greater probability that the jaw in question originally contained teeth of the form of those that I have referred to the *Hylæosaurus*.

The remains of the *Hylæosaurus* have been discovered in the Wealden formation in the following localities: Tilgate Forest, Bolney and Battle.

Iguanodon Mantelli, *Cuv.*

The bones of an enormous reptile, successively discovered in the Wealden strata by Dr. Mantell, interpreted by their discoverer with the aid of Cuvier and Clift‡, named *Iguanodon* by Conybeare§, lastly found in juxtaposition to the extent of nearly half the skeleton, in the green-sand quarries of Mr. Benstead, offer not the least marvellous or significant evidences of the inhabitants of the now temperate latitudes during the earlier oolitic periods of the formation of the earth's crust.

With vertebræ subconcave at both articular extremities, having, in the dorsal region, lofty and expanded neural arches, and doubly articulated ribs, and characterized in the sacral region by their unusual number and complication of structure; with a Lacertian pectoral arch and unusually large bones of the extremities excavated by large medullary cavities and adapted for terrestrial progression;—the *Iguanodon* was also distinguished by teeth, resembling in shape those of the Iguana, but in structure differing from the teeth of every other known Reptile, and unequivocally indicating the former existence, in the Dinosaurian Order, of a gigantic representative of the small group of living lizards which subsist on vegetable substances.

Of this remarkable Reptile, the results of personal examination of almost all the recognisable remains that have hitherto been collected in public or private museums, are here given.

Teeth.—The value of the ordinary external characters of the teeth of the oviparous Vertebrata has never perhaps been placed in so striking a point of view as in the leading steps to the discovery of the *Iguanodon*, which cannot be better recounted than in the words of Dr. Mantell.

* Part ii. p. 248. † Wonders of Geology, vol. i. p. 393.

‡ See Philosophical Transactions, 1825, "Notice on the *Iguanodon*, by Gideon Mantell, F.L.S."

§ "The name *Iguanodon*, derived from the form of the teeth (and which I have adopted at the suggestion of the Rev. W. Conybeare), will not, it is presumed, be deemed objectionable."—*Loc. cit.*

After noticing the ordinary organic remains which characterize the sandstone of the Tilgate Forest, and his discovery, in the summer of 1822, of other teeth distinguished by novel and remarkable characters, the indefatigable explorer of the Wealden proceeds to state*,—

"As these teeth were distinct from any that had previously come under my notice, I felt anxious to submit them to the examination of persons whose knowledge and means of observation were more extensive than my own. I therefore transmitted specimens to some of the most eminent naturalists in this country and on the continent. But although my communications were acknowledged with that candour and liberality which constantly characterizes the intercourse of scientific men, yet no light was thrown upon the subject, except by the illustrious Baron Cuvier, whose opinions will best appear by the following extract from the correspondence with which he honoured me:—

"'Ces dents me sont certainement inconnues; elles ne sont point d'un animal carnassier, et cependant je crois qu'elles appartiennent, vu leur peu de complication, leur dentelure sur les bords, et la couche mince d'émail qui les revêt, à l'ordre des reptiles; à l'apparence extérieure on pourrait aussi les prendre pour des dents de poissons, analogues aux tetrodons, ou aux diodons; mais leur structure intérieure est fort différente de celles-là. N'aurions-nous pas ici un animal nouveau, un reptile herbivore? et de même qu'actuellement chez les mammifères terrestres, c'est parmi les herbivores que l'on trouve les espèces à plus grande taille, de même aussi chez les reptiles d'autrefois, alors qu'ils étaient les seuls animaux terrestres, les plus grands d'entr'eux ne se seraient-ils point nourris de végétaux? Une partie des grands os que vous possédez appartiendrait à cet animal unique, jusqu'à présent, dans son genre. Le temps *con*firmera ou *in*firmera cette idée, puisqu'il est impossible qu'on ne trouve pas un jour une partie de la squelette réunie à des portions de mâchoires portant des dents. C'est ce dernier objet surtout qu'il s'agit de rechercher avec le plus de persévérance.'

"These remarks," Dr. Mantell proceeds to say, "induced me to pursue my investigations with increased assiduity, but hitherto they have not been attended with the desired success, no connected portion of the skeleton having been discovered. Among the specimens lately collected, some, however, were so perfect, that I resolved to avail myself of the obliging offer of Mr. Clift (to whose kindness and liberality I hold myself particularly indebted), to assist me in comparing the fossil teeth with those of the recent Lacertæ in the Museum of the Royal College of Surgeons. The result of this examination proved highly satisfactory, for in an Iguana which Mr. Stutchbury had prepared to present to the College, we discovered teeth possessing the form and structure of the fossil specimens."

The important difference which the fossil teeth presented in the form of their grinding surface was afterwards pointed out by Cuvier†, and recognised by Dr. Mantell‡, and the combination of this dental distinction with the vertebral and costal characters, which prove the *Iguanodon* not to have belonged to the same group of Saurians as that which includes the Iguana and other modern lizards, rendered it highly desirable to ascertain, by the improved modes of investigating dental structure, the actual amount of correspondence between the *Iguanodon* and Iguana in this respect. This I have endeavoured to do in my general description of the Teeth of Reptiles§, from which the following account is abridged.

* Notice on the *Iguanodon*, Phil. Trans. 1825.
† Ossemens Fossiles, 1824, vol. v. part ii. p. 351.
‡ Illustrations of the Geology of Sussex, 4to, 1827.
§ Odontography, part ii. p. 249; and Transactions of the British Association, 1838.

The teeth of the *Iguanodon*, though resembling most closely those of the Iguana, do not present an exact magnified image of them, but differ in the greater relative thickness of the crown, its more complicated external surface, and, still more essentially, in a modification of the internal structure, by which the *Iguanodon* equally deviates from every other known reptile.

As in the Iguana, the base of the tooth is elongated and contracted, while the crown is expanded, and smoothly convex on the inner side; when first formed it is acuminated, compressed, its sloping sides serrated, and its external surface traversed by a median longitudinal ridge, and coated by a layer of enamel, but beyond this point the description of the tooth of the *Iguanodon* indicates characters peculiar to that genus. In most of the teeth that have hitherto been found, three longitudinal ridges traverse the outer surface of the crown, one on each side of the median primitive ridge; these are separated from each other and from the serrated margins of the crown by four wide and smooth longitudinal grooves. The relative width of these grooves varies in different teeth; sometimes a fourth small longitudinal ridge is developed on the outer side of the crown. The marginal serrations, which, at first sight, appear to be simple notches, as in the Iguana, present under a low magnifying power the form of transverse ridges, themselves notched, so as to resemble the mammillated margins of the unworn plates of the elephant's grinder: slight grooves lead from the interspaces of these notches upon the sides of the marginal ridges. These ridges or dentations do not extend beyond the expanded part of the crown: the longitudinal ridges are continued further down, especially the median ones, which do not subside till the fang of the tooth begins to assume its subcylindrical form. The tooth at first increases both in breadth and thickness; it then diminishes in breadth, but its thickness goes on increasing; in the larger and fully formed teeth, the fang decreases in every diameter, and sometimes tapers almost to a point. The smooth unbroken surface of such fangs indicates that they did not adhere to the inner side of the maxillæ, as in the Iguana, but were placed in separate alveoli, as in the Crocodile and Megalosaur: such support would appear, indeed, to be indispensable to teeth so worn by mastication as those of the *Iguanodon*.

The apex of the tooth soon begins to be worn away, and it would appear, by many specimens, that the teeth were retained until nearly the whole of the crown had yielded to the daily abrasion. In these teeth, however, the deep excavation of the remaining fang plainly bespeaks the progress of the successional tooth prepared to supply the place of the worn out grinder. At the earlier stages of abrasion a sharp edge is maintained at the external part of the tooth by means of the enamel which covers that surface of the crown; the prominent ridges upon that surface give a sinuous contour to the middle of the cutting edge, whilst its sides are jagged by the lateral serrations: the adaptation of this admirable dental instrument to the cropping and comminution of such tough vegetable food as the *Clathruriæ* and similar plants, which are found buried with the *Iguanodon*, is pointed out by Dr. Buckland, with his usual felicity of illustration, in his 'Bridgewater Treatise,' vol. i. p. 246.

When the crown is worn away beyond the enamel, it presents a broad and nearly horizontal grinding surface, and now another dental substance is brought into use to give an inequality to that surface; this is the ossified remnant of the pulp, which, being firmer than the surrounding dentine, forms a slight transverse ridge in the middle of the grinding surface: the tooth in this stage has exchanged the functions of an incisor for that of a molar, and is prepared to give the final compression, or comminution, to the coarsely divided vegetable matters.

The marginal edge of the incisive condition of the tooth and the median ridge of the molar stage are more effectually established by the introduction of a modification into the texture of the dentine, by which it is rendered softer than in the existing Iguanæ and other reptiles, and more easily worn away: this is effected by an arrest of the calcifying process along certain cylindrical tracts of the pulp, which is thus continued, in the form of medullary canals, analogous to those in the soft dentine of the Megatherium's grinder, from the central cavity, at pretty regular intervals, parallel with the calcigerous tubes, nearly to the surface of the tooth. The medullary canals radiate from the internal and lateral sides of the pulp-cavity, and are confined to the dentine forming the corresponding walls of the tooth: their diameter is $\frac{1}{1\cdot256}$th of an inch: they are separated by pretty regular intervals equal to from six to eight of their own diameters; they sometimes divide once in their course. Each medullary canal is surrounded by a clear space; its cavity was occupied in the section described by a substance of a deeper yellow colour than the rest of the dentine.

The calcigerous tubes present a diameter of $\frac{1}{25,000}$th of an inch, with interspaces equal to about four of their diameters. At the first part of their course, near the pulp-cavity, they are bent in strong undulations, but afterwards proceed in slight and regular primary curves, or in nearly straight lines to the periphery of the tooth. When viewed in a longitudinal section of the tooth, the concavity of the primary curvature is turned towards the base of the tooth: the lowest tubes are inclined towards the root, the rest have a general direction at right angles to the axis of the tooth; the few calcigerous tubes, which proceed vertically to the apex, are soon worn away, and can be seen only in a section of the apical part of the crown of an incompletely developed tooth. The secondary undulations of each tooth are regular and very minute. The branches, both primary and secondary, of the calcigerous tubes are sent off from the concave side of the main inflections; the minute secondary branches are remarkable at certain parts of the tooth for their flexuous ramifications, anastomoses, and dilatations into minute calcigerous cells, which take place along nearly parallel lines for a limited extent of the course of the main tubes. The appearance of interruption in the course of the calcigerous tubes, occasioned by this modification of their secondary branches, is represented by the irregularly dotted tracts in the figure. This modification must contribute, with the medullary canals, though in a minor degree, in producing that inequality of texture and of density in the dentine, which renders the broad and thick tooth of the *Iguanodon* more efficient as a triturating instrument.

The enamel which invests the harder dentine, forming the outer side of the tooth, presents the same peculiar dirty brown colour, when viewed by transmitted light, as in most other teeth: very minute and scarcely perceptible undulating fibres, running vertically to the surface of the tooth, is the only structure I have been able to detect in it.

The remains of the pulp in the contracted cavity of the completely formed tooth are converted into a dense but true osseous substance, characterized by minute elliptical radiated cells, whose long axis is parallel with the plane of the concentric lamellæ, which surround the few and contracted medullary canals in this substance.

The microscopical examination of the structure of the Iguanodon's teeth thus contributes additional evidence of the perfection of their adaptation to the offices to which their more obvious characters had indicated them to have been destined.

To preserve a trenchant edge, a partial coating of enamel is applied; and,

that the thick body of the tooth might be worn away in a more regularly oblique plane, the dentine is rendered softer as it recedes from the enameled edge by the simple contrivance of arresting the calcifying process along certain tracts of the inner wall of the tooth. When attrition has at length exhausted the enamel, and the tooth is limited to its function as a grinder, a third substance has been prepared in the ossified remnant of the pulp to add to the efficiency of the dental instrument in its final capacity. And if the following reflections were natural and just after a review of the external characters of the dental organs of the *Iguanodon*, their truth and beauty become still more manifest as our knowledge of their subject becomes more particular and exact:—

"In this curious piece of animal mechanism we find a varied adjustment of all parts and proportions of the tooth, to the exercise of peculiar functions, attended by compensations adapted to shifting conditions of the instrument, during different stages of its consumption. And we must estimate the works of nature by a different standard from that which we apply to the productions of human art, if we can view such examples of mechanical contrivance, united with so much economy of expenditure, and with such anticipated adaptations to varying conditions in their application, without feeling a profound conviction that all this adjustment has resulted from design and high intelligence." —*Buckland's Bridgewater Treatise*, vol. i. p. 249.

Head.—Two fragments of jaw with alveoli, in the Mantellian Collection, are referred by its founder to the *Iguanodon*: in neither of them, unfortunately, is a tooth with the characteristic crown preserved: the size of these specimens proves them to have belonged, if to this genus, then to young individuals. The smaller fragment is described in this Report under the head of *Hylæosaurus*, on account of the cylindrical, equal, and straight form of the remaining fangs. These parts correspond with the fangs of the teeth which I suppose to belong to the *Hylæosaurus*, rather than with those of the *Iguanodon*, which are angular, curved, taper towards a point, and support crowns so expanded, as to require greater intervals between their fangs than in the fossil. It is just possible that these differences may depend on age*.

Tympanic bone.—A reptile with vertebræ and ribs resembling in their chief characters those of the cœlospondylian Crocodiles, and with distinctive peculiarities, in which the Lacertians by no means participate, might reasonably be conjectured to resemble the Crocodiles in the form of the tympanic bone; and if the reptile in question used its teeth for masticating hard vegetable substances, we might with more reason expect that the bony pillar supporting the lower jaw should be firmly and immoveably fixed through its whole length, like the tympanic bone of the Crocodilians, and not be loosely suspended to the skull by a single extremity, as in the Iguana and other Lacertians. A very remarkable bone discovered in the Tilgate strata, figured by Dr. Mantell in the 'Geology of the South-east of England,' pl. ii. fig. 5, the resemblance of which to the 'os quadratum,' or tympanic bone of birds, was first suggested by Dr. Hodgkin, is assigned to the *Iguanodon* by Dr. Mantell. He accurately describes it "as forming a thick pillar or column, which is contracted in the middle, and terminates at both extremities in an elliptical and nearly flat surface." In the Iguana and other reptiles the lower end of the tympanic bone is terminated by a convex trochlea, which is received into a corresponding cavity in the lower jaw. Is the modification of the bone in question, assuming it to belong

* In the Monitor-lizards of the modern genera *Thorictes* and *Crocodilurus*, the posterior teeth in the young individuals have more or less compressed and tri-cuspidate crowns, but in the old animals they have round obtuse crowns, adapted for true mastication. Some modification analogous to this may take place in the *Iguanodon*.

to the *Iguanodon*, indicative of a peculiarity of the joint of the lower jaw as remarkable as the structure of the teeth, and correlated to their masticatory uses? "Two lateral processes, or *alæ*, pass off obliquely, and are small in proportion to the size of the column; on placing these bones beside the os tympani of an Iguana, we at once perceive that the relative proportions of these parts are reversed; for in the recent animal the pillar is small and the lateral processes large. From the great size of the body of the fossil, and the extreme thinness of its walls, the *tympanic cellulæ* must have been of considerable magnitude, and have constituted a large portion of the auditory cavities. Pl. ii. fig. 1., (fig. 5 is meant,) accurately represents the most perfect specimen in my cabinet; it is 6 inches high, and $5\frac{1}{2}$ inches wide at the longest diameter of the extremity of the body. It exceeds in magnitude the corresponding bone of the *Mosasaurus*, and is fourteen times as large as the same bone in an Iguana 4 feet long." *Loc. cit.*, p. 306.

Vertebral Column.—The vertebræ of the *Iguanodon* have their bodies terminated by flat or slightly concave articular surfaces*, and their sides flat or slightly convex vertically, moderately concave lengthwise or in the axis of the vertebra; the sides converge more or less towards the under surface, and the body accordingly presents more or less the form of a wedge, with its edge obtuse or flattened in the dorsal vertebræ, but slightly concave, and with its anterior and posterior angles truncated in the caudal vertebræ†. The contour of the terminal surfaces is nearly circular, with the vertical slightly exceeding the transverse diameter. The neural arch of the dorsal vertebræ presents the complicated exterior, the great height and superior expansion, which characterize these vertebræ in other Dinosaurs: the base of each neurapophysis equals, or nearly equals, the antero-posterior extent of the centrum, but immediately contracts in this direction from the posterior margin, which then curves backwards as it inclines towards the opposite neurapophysis, and the conjoined laminæ are developed beyond the posterior end of the centrum to an extent varying in the different regions of the spine. In the dorsal vertebræ the bases of the neurapophyses are developed transversely inwards, so as to meet and join each other below the spinal canal: the hæmapophyses present an analogous structure through a great part of the tail, the bases of each pair, as well as the apices, being united together, and the chevron bones, thus formed, are perforated instead of being notched for the passage of the great blood-vessels. The neurapophyses are commonly anchylosed to the centrum, with a persistent trace of the suture. The transverse processes are straight, and of great length in the vertebræ from the middle of the trunk, indicating there a considerable expanse of the abdominal cavity, adapted for the lodgement of the capacious viscera of a herbivorous feeder. The spinous processes rise to a considerable height in the dorsal, as well as in the anterior caudal vertebræ. The exterior surface of the vertebræ is impressed with fine striations, which are mostly longitudinal in the centrum; so that fragments may thus be distinguished from the characteristically smooth and polished vertebræ of the *Megalosaurus*. The antero-posterior diameter of the largest vertebræ of the *Iguanodon* which I have yet seen is $4\frac{1}{2}$ inches; the most usual size is 4 inches.

Having premised these general characters of the vertebræ of the *Iguanodon*, there next remain to be considered the modifications by which they are

* The plano-concave vertebræ in the Mantellian Collection, British Museum, belong to the *Cetiosaurus*.

† The large vertebræ from the Wealden, with obscurely quadrangular or hexagonal bodies, which are rather convex or flat on one side and concave on the other, belong to the *Cetiosaurus*.

distinguished in different regions of the spinal column. Hitherto I have not met with any specimen of a cervical vertebra; the comparatively small fractured vertebra, Nos. $\frac{437}{2437}$ and $\frac{438}{2438}$, "Axis of the *Iguanodon*," Mantell. Catal., is an ordinary, or more posterior, cervical vertebra of a large Crocodilian Reptile, which, if not belonging to the *Poikilopleuron*, indicates a species distinguishable from all other known Saurians*. The large cervical vertebræ with ball-and-socket articular surfaces, agreeing with the *Iguanodon* in size, have been shown to have these surfaces the reverse in position to those in the Iguanæ and modern Saurians, and to belong to the genus *Streptospondylus*. The desirable knowledge, therefore, of the anatomy of that region of the spine in the *Iguanodon*, which in other Saurians is usually distinguished by its well-marked and varied characters, remains to be acquired.

Costal or dorsal vertebræ†.—Towards the middle or anterior part of this region the bodies of the vertebræ are laterally compressed, and meet below at an obtuse ridge. Through, apparently, a considerable proportion of the dorsal region of the spine, the neurapophyses rise vertically to a height equal to that of the centrum, and expand into a broad and strong platform, the upper surface of which is slightly concave transversely, and arched from behind downwards and forwards in a regular curve; this platform is supported by a strong vertical buttress on each side, and sends upwards from the whole of its middle line a thick, broad and high spinous process. Two oblique, flat, articular processes look downwards and outwards from the posterior angles of the platform; and the corresponding anterior oblique processes, having their flat articular surfaces looking upwards and inwards, and inclining to each other at a right angle, terminate the contracted anterior part of the platform, and do not project beyond it as two distinct processes separated by a median fissure. They are not continued beyond the anterior end of the body of the vertebræ, and consequently the posterior processes overhang the hinder

* A portion of this vertebra is alluded to at p. 137, and figured at pl. ix., fig. 1, of Dr. Mantell's Memoir on the *Iguanodon*, published in the Philosophical Transactions for the present year, 1841, as the "atlas of a young *Iguanodon*;" its position in the neck has been apparently determined by the resemblance of the cast of calcareous spar, which fills up the spinal canal, to the medulla oblongata. This resemblance arises from the expansion of the open ends of the canal; in which expansions, in the recent Crocodile, the contained spinal chord does not, however, in the least degree participate. The longitudinal fissure in the cast is due to a corresponding ridge of bone projecting from the inner surface of the contiguous wall of the spinal canal; doubtless giving attachment to the dura mater of the chord, but not impressing the chord itself. The external surface of the vertebra exhibits an upper and a lower transverse process for the attachment of a bilobed cervical rib, which unequivocally demonstrates it not to agree with the Lacertian type of structure.

† In the Memoir in the Philosophical Transactions, 1841, above quoted, Dr. Mantell says, "The usual characters of the dorsal and caudal vertebræ of the *Iguanadon* have been pointed out in my former works," and refers to the 'Fossils of Tilgate Forest,' and the 'Geology of the South-east of England,' p. 136. I have again, therefore, carefully perused the passages in which the structure of the vertebræ from the Wealden strata is alluded to in those valuable works, in the hope that the present tedious section of my Report might be cancelled; but they leave the same doubt, which their first perusal occasioned, as to whether the author intended to attribute to the vertebræ of the *Iguanodon* the characters of those of the second system of Wealden vertebræ, viz. *Cetiosaurus*; or those of the fourth system, viz. *Streptospondylus*. See Geology of the South-east of England, p. 306. M. H. v. Meyer adopts the former, or the Cetiosaurian type, for his characters of the Iguanodon's vertebræ, from the works to which Dr. Mantell refers. The six caudal vertebræ of the *Iguanodon* described in the Memoir of 1841, are referred to, in the 'Geology of the South-east of England,' at the conclusion of the account of the *Hylæosaurus*, and the accomplished author there states, "The bodies of these vertebræ, like those of the newly-discovered reptile, are slightly concave at both extremities," which is one of the characters whereby they might be distinguished from the vertebræ of the *Cetiosaurus*.

surface of the centrum in order to rest upon the oblique processes of the vertebra next behind. In the anterior dorsal vertebræ the body supports a large and well-marked articular surface on each side, for the head of the rib; and a long and strong transverse process is developed from each neurapophysis against the end of which the tubercle of the rib abuts, as in the Crocodile. In the hinder costal vertebræ the long transverse process is gradually narrowed to its extremity, which is abruptly truncated, and has a right-angled notch at the anterior part; the curtailed neck of the rib, no longer expanded into a head or joined to the body of the vertebra, is fitted into this notch, and the broad and flat surface, at right angles to the neck, is adapted to the extremity of the transverse process.

We seek in vain, in the existing Iguana, for such modes of articulation of the ribs as have here been described, while they are common to Crocodiles with the Dinosaurs. The fact of the complete inclosure of the spinal canal by the meeting and confluence of the bases of the neurapophyses beneath it, was first brought to my attention by the appearances in the body of a dorsal vertebra of the great Horsham *Iguanodon*, in the collection of Mr. Holmes. This centrum, which measures $4\frac{1}{2}$ inches in length and 5 inches across its articular extremity, presented only a slight trace of the impression of the spinal canal at the anterior part of its upper surface, the rest being occupied by a slightly concave, continuous, rough articular surface. The deficiency of this vertebra was supplied by a fine specimen in Mr. Saull's collection of the separate neural arch of a dorsal vertebra of a corresponding size, which seemed to have been detached from a natural articulation. I saw with much interest that the bases of the neurapophyses met and joined each other below the spinal canal along the posterior half of their longitudinal extent, presenting at their under part a continuous slightly convex surface, which must have left a corresponding concave rough articular surface upon the upper part of the centrum, like that exhibited by the Horsham vertebral body. The base of each neurapophysis, which is longer than it is wide, describes a slight curve, convex in the antero-posterior direction, downwards or towards the centrum. The spinal canal is nearly cylindrical, very slightly expanded at the two extremities; its diameter 1 inch 5 lines. The chief buttress of the spinal platform rises from the posterior and outer part of the base of the neurapophysis, and ascends almost vertically, slightly inclining forwards; it is compressed, with its plane transverse to the axis of the vertebra; it expands as it blends with the under part of the broad platform, half-way between the anterior and posterior boundaries of that remarkable part of the neurapophysis. A second buttress rises from the anterior part of the base of the neurapophysis, and ascends vertically to the upper and outer end of the anterior oblique processes. The base of the transverse process is situated above the converging point of the two buttresses. In the interspace of the two buttresses of the anterior dorsal vertebræ there is a large oval articular surface, convex at the anterior and concave at the posterior part, which has afforded a lodgement to the head of an enormous rib. The oblique or articular processes, directed as described in the general observations on the vertebræ of the *Iguanodon*, converge and meet at nearly a right angle. There is a wide depression at the posterior broad part of the base of the spine, and a wide and deep fossa between the posterior buttress and the posterior oblique process. The base of the spine, as it extends forwards along the middle of the broad platform, descends with a graceful curve to the interspace of the anterior oblique processes. The platform recedes on each side from the base of the broad spine with a regular concavity to its plane; its surface is coarsely striated transversely.

The following are dimensions of this interesting fossil:—

	In.	Lin.
Length of the base of the neurapophysis*	4	6
From the base of the neurapophysis to the middle of the base of spinous process	5	0
From the base of the neurapophysis to the posterior part of the base of spinous process	6	0
From the base of the neurapophysis to the anterior part of the base of spinous process	3	6
Antero-posterior extent of base of spinous process	6	6
Transverse diameter of spinal platform	8	6
Transverse diameter of conjoined bases of neurapophyses†	4	0
Extent of spinal platform beyond hind part of base of neurapophysis	4	0

The spinous process is broken off near its base in this specimen, which is otherwise remarkably entire, considering that it was washed out of the submerged beds of the Wealden and cast on the south shore of the Isle of Wight. It was found near Culver Cliff.

The characters thus obtained from two different parts of the vertebræ of two Iguanodons from distant localities, certified to belong to that genus from the association of one of the parts, viz. the vertebral centrum, with many other characteristic bones of that reptile, have their value increased from the circumstance of the obscure and unsatisfactory manner in which the vertebral characters are exhibited in the celebrated specimen from the Maidstone quarry. The eight vertebræ originally forming a continuous series in this specimen are from about the middle of the back; the antero-posterior diameter of each is $3\frac{1}{2}$ inches. Little more can be determined from these or from the detached and crushed dorsal vertebræ in this specimen, except the flattening of the sides of the vertebræ and their convergence to the lower surface, the slight concavity of both articular extremities, the height of the neural arch, and the strength and length of the transverse and spinous processes.

With the evidence afforded by the previously described specimens, the characters afforded by the following detached vertebræ from the Tilgate strata may with confidence be applied to the further elucidation of the osteology of the *Iguanodon*.

An anterior dorsal vertebra (No. $\frac{160}{2160}$, Mantellian Collection), having the following dimensions of the centrum,—

	In.	Lin.
Antero-posterior diameter	3	11
Vertical diameter of articular end	4	1
Transverse diameter of articular end	3	2

measures, from its under surface to the posterior part of the base of the spinous process, 8 inches. The broad and high neural arch is anchylosed with the centrum, but the nearly straight line of suture is indicated by numerous puckered rugæ and striæ. The transverse process extends from the side of the neurapophysis; its base is vertically oval, measuring $2\frac{1}{2}$ inches by 2 inches. The neurapophysis expands above this surface into a broad platform, with a thick rough external free border, probably fractured. The platform is supported by a buttress-like ridge, rising vertically from the posterior angle of the base of the neurapophysis, and expanding as it ascends to blend with the under part of the overhanging platform. Behind this buttress is a

* This doubtless gives the length of the centrum to which it was attached.

† At their anterior and broader part.

wide and deep depression, and the neurapophysis extends backwards to form the posterior articular processes which project $1\frac{1}{2}$ inch beyond the hind surface of the centrum. The antero-posterior extent of the neurapophysial platform is 6 inches; the dimensions of the oval articular surfaces of the oblique processes are 2 inches by $2\frac{1}{2}$ inches; the inferior margins of the posterior processes are separated by a groove. A smaller anterior ridge extends along the anterior part of the neurapophysis. The base of the spinous process extends from the posterior triangular interspace of the oblique processes forwards and downwards along the curve of the supporting platform; the thickness of the spine, which is 1 inch at the posterior part of the base, gradually diminishes towards the fore part of the vertebra. The anterior oblique processes form the sides of an angular depression in front of the base of the spine.

The spinal platform of the *Iguanodon* differs from that of the *Megalosaurus* in its greater relative antero-posterior extent, arising from its being extended further back; the platform is also raised higher above the centrum.

No. $\frac{556}{2556}$, Mantellian Collection, is a dorsal vertebra, posterior in situation to the preceding, and from an individual of the same size. The neural arch is anchylosed, but the sutural line is obvious. The surface for the head of the rib on the side of the neurapophysis is smaller, and a transverse process begins to be developed above that surface, throwing its aspect somewhat downwards. The costal surface is separated in this as in the preceding vertebra by a strong vertical ridge or buttress from the wide depression below the posterior part of the base of the spine. The angle between the oblique processes is rather more open. The spinous process of this vertebra, almost entire, is detached from the neural platform, but is cemented to the same mass of stone: it is 9 inches in height and 3 in breadth, or antero-posterior extent; the summit is, however, wanting. The following are other dimensions of the present vertebra:—

	In.	Lines.
Antero-posterior extent of the body	3	10
Vertical diameter of the body	3	9
Transverse diameter of the body	3	7

The sides of the centrum are as usual concave lengthwise, but are slightly convex vertically, and converge to the lower surface, which is formed by an obtuse ridge.

In a dorsal vertebra of the Horsham *Iguanodon* in Mr. Holmes's collection, from apparently the middle of the back, the spinous process, which is 8 inches in length, expands gradually in breadth and thickness as it ascends to its truncated summit, the antero-posterior diameter of which is 4 inches, its transverse diameter or thickness being 1 inch 6 lines.

In a series of eight posterior dorsal vertebræ, measuring together 1 foot, and consequently from a young *Iguanodon* in Mr. Holmes's collection, the spinous process of the most anterior one is, in antero-posterior diameter, 7 lines, but increases in the other vertebræ to 15 lines, which shows a somewhat rapid change of character.

Sacral Vertebræ.—The highly remarkable and characteristic structure of the sacrum of the *Megalosaurus*, and the strong indications of close affinity between this gigantic carnivorous reptile and the still more colossal herbivorous *Iguanodon*, which the structure of their costal vertebræ, of their ribs, and of the larger bones of their extremities afford, made it very desirable to ascertain whether the *Iguanodon* deviated in the same manner from other Saurians, existing and extinct, in the extent and structure of the sacral region of the spine.

The collection of the remains of the *Iguanodon* in the British Museum does

not include this characteristic part of the skeleton; it does not form part of the series of bones obtained by Mr. Holmes from the Wealden Quarry at Horsham; but in the collection of rolled bones of the great Wealden Saurians—*Cetiosaurus*, *Streptospondylus*, and *Iguanodon*—in the museum of Mr. Saull, there is a fine specimen of the sacrum with one of the iliac bones attached, which, in the proportions of the vertebræ and the form of the ilium, agrees with the known characters of the *Iguanodon*.

This instructive specimen consists of five vertebræ anchylosed together by the articular surfaces of their bodies and by their spinous processes, which seem to form a continuous thick median ridge of bone. The five vertebræ measure 17 inches in length. The articular extremity of the terminal sacral vertebra is very slightly concave and subcircular, measuring 3 inches in both vertical and transverse diameter. The bodies of the dorsal vertebræ are compressed at their middle part, and broader below than in the dorsal region, and concave in the direction of their axis, the concavities being separated by the broad prominent convex transverse ridges formed by the anchylosed and ossified intervertebral spaces. The contour of the under part of the sacrum thus forms an undulating line. The lateral and inferior surfaces are separated by a more angular prominence of the centrum, the under surface is less convex transversely, and the whole centrum is shorter in proportion to its depth and breadth, than in the *Megalosaurus*. The neurapophyses present the same remarkable modification in regard to their relations to the body of the vertebra as in the *Megalosaurus*, having shifted their position from the upper surface of a single centrum to the interspace of two, resting on proportions of these, which are more nearly equal, as the vertebræ are nearer the middle of the sacrum. The nerves were compelled therefore to escape from the spinal canal over the body of the vertebra, more or less near its middle, and they impress the upper surface there with a smooth canal.

The strong, vertically compressed, transverse processes, or sacral ribs, rise from the bases of the neurapophyses, and their origin extends upwards upon the spine, and downwards upon the sides of the contiguous vertebral bodies and intervertebral space; in the specimen described they are firmly anchylosed to all these parts, extend outwards and expand at their extremities, four of which meet, join, and form an elongated tract of varying breadth to which the ilium is firmly attached. The length of the largest penultimate transverse process was 5 inches 8 lines, its vertical breadth at the middle 3 inches, its thickness here 1 inch. The adjoining (last) transverse process was 5 inches in length; the interspaces of the transverse processes equalled from $2\frac{1}{2}$ inches to 2 inches. The sacrum increases in breadth posteriorly; its transverse diameter, including the anchylosed ilia taken at the posterior part of the acetabulum, is 13 inches, at the anterior part of the sacrum only 8 inches. The proportion of the spine thus grasped, as it were, by the iliac bones, which transmit the weight of the body upon the thigh-bones, corresponds with the mass which is to be sustained and moved; and the size and structure of the sacrum indicate, with those of the femur and tibia, the adaptation of the present great herbivorous Saurian for terrestrial life.

No. $\frac{127}{2127}$, Mantellian Collection, is the centrum of a sacral vertebra of a subquadrate form, with a broad and flattened inferior surface, slightly concave antero-posteriorly. The upper surface is excavated by a wide and moderately deep canal, indicating the unusual size, for Reptiles, of the sacral portion of the spinal chord. The anterior and posterior parts of the sides of this centrum are raised, so as to form projecting sub-triangular rough articular surfaces, continued upon the margins of the spinal canal, evidently for the attachment of the neurapophyses and the heads of the strong sacral ribs. The

interspace of these anterior and posterior neurapophysial surfaces is formed by a smooth oblique groove, connecting the smooth surface of the spinal canal with that of the free lateral surface of the vertebra, and indicating the place of exit of the sacral nerves, which is necessarily in this unusual situation, because the ordinary holes of conjugation must have been obliterated by the impaction of the bases of the neurapophyses between the contiguous extremities of the bodies of the sacral vertebræ.

The anterior and posterior articular extremities of the present interesting fossil equally bespeak the peculiar character of the sacral vertebræ of the *Dinosauria*. They are impressed by coarse straight ridges and grooves radiating from near the upper part of the surface, like those on the corresponding part of a cetaceous vertebra when the epiphysial articular extremity is removed. These inequalities are here, doubtless, preparatory to that anchylosis by which the sacral vertebræ are compacted together in the mature Dinosaurs.

	In.	Lines.
The length of this vertebra	2	10
The height	2	6
The breadth of anterior articular end	3	0
The breadth of middle	2	2
Antero-posterior diameter of anterior costal surface	1	7
Antero-posterior diameter of posterior one	1	0
Breadth of spinal canal	1	5
Breadth of canal of sacral nerve	0	4

From its separated condition, the body of the sacral vertebra here described must have belonged to a young Dinosaur of a size far exceeding that of the *Hylæosaurus*. It is obviously very distinct in form from the sacral vertebræ of the *Megalosaurus*. No other reptile than one belonging to the order characterized by the peculiar structure of the sacrum already described, could have yielded a detached vertebral centrum with the remarkable modifications of the one under consideration. The modifications detected in the entire sacrum of the *Iguanodon* in Mr. Saull's collection, justify the reference of the vertebra above described to the sacrum of a young *Iguanodon*.

Caudal Vertebræ.—These are distinguished by the single hæmapophysial surface at each end of the narrow inferior surface of the centrum. The sides of the centrum are flat, or even slightly concave in the vertical direction, though less so than in the antero-posterior direction. In a caudal centrum, for example, in the Mantellian Collection, measuring 4 inches in length, and 5 inches 4 lines in depth at the middle of the side, if a pencil be laid vertically along that part, an interval of between 1 and 2 lines separates its middle part from the bone. Those great Wealden vertebræ which, on the contrary, have the middle of the side of the body prominent, and the lower half only converging towards the under surface, are from the middle and posterior part of the tail of the *Cetiosaurus*. The posterior terminal articular surface is rather more concave than in the dorsal vertebræ; but the difference is by no means so marked as in the plano-concave vertebræ of the *Cetiosaurus*. The transverse processes of the anterior caudal vertebræ are comparatively short, but strong, and are continued from the base of the neurapophysis.

The hæmapophyses, or chevron bones, are not anchylosed to the centrum, but articulate with the interspaces of the vertebræ; in a few of the anterior ones to two distinct but closely approximated surfaces on each contiguous vertebra, but in the rest of the caudal vertebræ to a single oblique triangular surface on each of the contiguous extremities of the centrum; the hæmapo-

physes being here confluent at their vertebral as well as at their distal extremities.

A caudal vertebra exhibiting this modification in Mr. Holmes's collection measures, in the vertical diameter of the articular surface, 4 inches 9 lines; in its transverse diameter, 4 inches 6 lines; the breadth of the inferior surface of the vertebra is 3 inches 3 lines. The interspace between the anterior and posterior hæmapophysial surface is 9 lines; it is concave in the axis of the vertebra. The diameter of the spinal canal is reduced in this vertebra to 9 lines. The transverse processes are of very small size. The spinous process is broken off. We have seen that those of the sacral vertebræ appear to have been short. There is reason to think that the spinous processes increased in length for a certain distance as they receded from the sacrum, and then diminished. Thus, in a caudal vertebra (No. $\frac{130}{2130}$, Mantellian Collection), evidently anterior in position by its size, by its oblique processes, and by the place of development of its transverse processes from the base of the neural arch, the spinous process is 5 inches in height, while in the six caudal vertebræ preserved in natural sequence and relative position in the Mantellian Collection, the spines are more than double that height. That the vertebra (No. 2130) is not a more posterior caudal vertebra from a larger *Iguanodon* is shown by the relative thickness, as well as position, of its transverse processes, as compared with the six caudal vertebræ above mentioned, for their transverse processes sensibly diminish in every diameter, and especially in vertical thickness, from the first to the sixth; and, moreover, it is evident that, in this short series, the spines decrease in height both forwards from the third as well as backwards, but more so in the latter direction. Thus the spine of the first of these vertebræ is 14 inches high, of the third 15 inches, and of the sixth 13 inches. These spines increase in breadth toward their summits, which are truncated, and in contact with each other, partly from this expansion, partly from the posterior ones being slightly bent forwards. One cannot witness this change of character in so short a segment of the tail without a conviction that this appendage must have been relatively shorter than in the Iguana.

The first spine, besides being somewhat shorter, is more rounded off at its anterior margin than the third, a difference which is still more obvious in the detached caudal above described; but above its origin a thin trenchant plate is extended for a short distance from the middle of the anterior margin: this character, which calls to mind one that is present in a greater proportion of the vertebral column in the Crocodilians, is more strongly developed in the second and third vertebræ. The neurapophysial suture is more nearly obliterated in the sixth than in the first of this instructive series, or in the more anterior and detached caudal vertebra. The following are dimensions of the detached anterior caudal (No. 1), and of the first (No. 2) and last (No. 3) of the series of six:—

	No. 1.		No. 2.		No. 3.	
	In.	Lin.	In.	Lin.	In.	Lin.
Antero-posterior diameter of centrum . . .	2	8	2	8	2	7
Vertical diameter of articular surface . . .	3	6	3	3	2	6
Transverse diameter of articular surface . .	3	5	3	2	2	6
From under part of centrum to upper end of posterior articular process	5	6	5	8	4	0
From upper end of posterior oblique process to the summit of spine	5	0	14	0	10	6
Antero-posterior diameter of base of spine .	1	3*	1	7	1	4
Antero-posterior diameter of summit of spine	2	0	2	2	2	6

* The anterior basal ridge of this vertebra is broken away.

The transverse processes disappear in the posterior caudal vertebræ. The chevron bones, of which three are preserved in the slab containing the six caudal vertebræ, exhibit the perforated character which distinguishes them from those of the *Cetiosaurus* and of all existing Crocodiles and Lizards, not excepting the Iguana, in which the hæmapophyses are anchylosed at their distal or spinal end only, and remain separate and articulated to two distinct surfaces, at their proximal ends. The length of the superior and inferior vertebral spines, and the shortness of the transverse processes, prove the form of the tail to have been flattened laterally and of great breadth in the vertical direction, at its basal portion at least.

Ribs.—These appendages of the vertebral column are largely developed in the thoracic abdominal region of the spine, and had the same two-fold connexion with the vertebræ as in the other Dinosaurs and the Crocodilians. At the anterior part of the costal region of the spine, the rib was joined by a large head to a shallow cavity, situated at first on the side of the centrum and then on the side of the neurapophysis; and it was further articulated by a tubercle to the extremity of the transverse process. In a certain number of the anterior vertebræ, the neck of the rib was co-extensive with the transverse process, and sometimes six or seven inches in length; afterwards the neck of the rib began to shorten, and the head to decrease in size, and to have its place of articulation brought progressively nearer to the end of the transverse process, until it finally disappeared, and the posterior ribs became appended to the ends of the transverse processes.

In the Iguana, as in other Lizards, the ribs have but one mode of articulation, viz. to a simple tubercle developed from the side of the centrum.

One of the largest double-jointed ribs of the *Iguanodon*, in the Mantellian Collection (No. $\frac{519}{2519}$), is 46 inches in length. The neck is less distinct from the tubercle and body than in other ribs, which seem to have been situated further back; it expands more gradually to the tubercular articulation with the transverse process, and is at this part 5 inches in breadth; it bends with a deep oblique curve for about one-fifth of its length, and then is continued in a nearly straight line to its extremity: this is slightly expanded and truncated, for the attachment doubtless of a bony sternal rib. The convex or outer margin of the rib is bent backwards so as to overhang the sub-compressed shaft of the bone along its upper or proximal third part.

The proximal extremity of one of the ribs from the middle of the trunk of the Horsham *Iguanodon*, presents an ovate head $2\frac{1}{2}$ inches in the long diameter; the neck is 7 inches long, straight, compressed, and topped by a well-marked tubercle, where it joins the body of the rib. This part is also compressed; and its external margin, besides being bent backwards, is also developed in the contrary direction, so as to assume the form of a slightly convex plate of bone 2 inches broad, attached at right angles to the shaft of the rib, which it overhangs on both sides. This structure is characteristic also of some of the ribs in the other Dinosaurs, and is interesting as indicating the commencement of that peculiar development of the corresponding part of the ribs in the Chelonian reptiles, by which the upper part of their bony box is almost wholly formed.

Bones of the Extremities.

Scapular Arch.—The scapula has not hitherto been discovered so associated with other unequivocal portions of the skeleton of the *Iguanodon* as to permit the characters of this bone in that species to be confidently recognised. The bone (No. 194, Omoplate of *Iguanodon*, Mantell. Catal.) agrees with

the undoubted scapula of the Hylæosaur, and with that of certain Lacertians, especially of the genus *Scincus**, in the production of a long and slender pointed process, continued at nearly right angles with the body of the bone, from the anterior part of the articular surface for the coracoid; but it differs from the scapula of the Hylæosaur in the presence of two short processes given off from the lower part of the base of the long process, and in the absence of the thick and strong transverse acromial ridge which overarches the glenoid depression, and in the deeper concavity of the posterior margin of the ascending plate or body of the bone. This part, in its shape, relative length and breadth, is intermediate between the Crocodilian and Lacertian type of the scapula, at least as exemplified in the Monitors and Iguanas, where it is broad and short. The Scincs and Chameleons, in the more Crocodilian proportions of their scapulæ, resemble the Hylæosaur and the great species of extinct Saurian, most probably the *Iguanodon*, to which the present bone belongs.

Coracoid.—The thick articular portion of this bone, with its characteristic perforation, here continued to the articular margin by a narrow fissure, dividing the scapular from the humeral articulation, has been found of different sizes in the Tilgate strata, and has been, with much probability, likewise referred to the *Iguanodon*. One of these portions of coracoid, which measured 10 inches in diameter, was found in the same block of stone with other unequivocal remains of *Iguanodon*.

Clavicle.—The doubts which are attached to the determination of the previous parts of the scapular arch are fortunately dissipated from the consideration of this bone by the preservation of both the right and left clavicles in the Maidstone *Iguanodon*. The presence of the fibula in the same block of stone, and its discovery in close proximity with the tibia and femur in the Wealden strata, satisfactorily prove that the present remarkable bone cannot have formed part of the hinder extremity. And since, in other reptiles, the radius differs from the fibula in little more than in being somewhat shorter and thicker, there is still less reason for supposing it to belong to the fore-arm.

The form of the ribs of the *Iguanodon* is well known, and they become shorter and more curved as they advance from the middle to the anterior part of the chest. The determination, therefore, which Dr. Mantell regarded as most probable †, must be held to be the true one. The largest entire clavicle from the Wealden strata measures 29 inches in length, and there is a portion of another in the same collection one-third larger. The largest fibula of the *Iguanodon* that has been found measures 28 inches. The bone is compressed, slender, and subtrihedral at the middle part, expanded and flattened at the two extremities, bent with a slight double curve in a graceful sigmoid form. The broadest end, which, from the analogy of the Cyclodus lizard, must be regarded as the median or pectoral extremity, gives off two processes, the first appearing as a continuation of the thinner margin of the bone, twisted and produced obliquely downwards; the second process is given off nearer the expanded sternal end, towards which it slightly curves.

* Dr. Mantell has pointed out this resemblance in his Memoir in the Phil. Trans., 1841.

† "If we consider the form of this bone, it appears that the only place it can hold in the skeleton must be either the thorax or lower extremities; it may be a fibula, a rib, or a clavicle; and that it is a clavicle of some extraordinary extinct reptile is certainly most probable."—Geology of the South-east of England, p. 309. The subsequent discovery of the Maidstone *Iguanodon* determined the species of reptile to which the bone in question belonged, and the comparisons mentioned in the text prove it to be a clavicle. The bone attached to the coracoid and omoplate of a small lizard, which I pointed out to Dr. Mantell as resembling the one in question, was the clavicle of the *Cyclodus nigroluteus*. See Dr. Mantell's late Memoir of 1841, Phil. Trans., p. 138.

	In.	Lin.
The breadth of the expanded sternal end of a clavicle, 29 inches in length, is	3	7
The breadth of the scapular end	4	3
From this extremity to the base of the first process	19	0
The breadth of the narrowest part of the shaft	1	7

Humerus.—This important bone has not been hitherto satisfactorily determined; it differs less from the femur in form in Reptiles than in Mammalia. In the Crocodilians it is shorter than the femur, especially in the extinct piscivorous species, with biconcave vertebræ and more strictly aquatic habits. In Lizards it is more nearly equal with the femur, and the similarity of the size of these bones we may conceive to have been greater in the gigantic terrestrial Dinosaurs.

In the modern Crocodiles, the chief distinction in the form of the humerus is the ridge at the upper third of the bone: in Lizards this distinction is almost lost. If we find the femur of the *Iguanodon* distinguished from that of all other reptiles by the presence of a peculiar process from the inner side of the bone, there are not wanting grounds to expect that the humerus may present a similar character.

As the reasons for suspecting that some of the large bones, hitherto uniformly regarded as the femora, may be the humeri of the *Iguanodon*, will best appear in the description of the femur, I shall now proceed to the consideration of the large bones with which the femur is articulated.

Ilium.—The iliac bone of the *Iguanodon** resembles in form that of the Monitor more than that of the Iguana: in the portion of the pelvis in Mr. Saull's collection it measured 14 inches in length. It commences anteriorly by a thick obtuse extremity slightly bent outwards; this part is supported by the thickest and strongest of the sacral ribs, which slightly inclines backwards: the ilium quickly increases in vertical as well as transverse extent, forming at its lower part the usual portion of the acetabulum; the concavity terminating behind in a broad obtuse prominence: behind this part the ilium rapidly contracts, by a deep inferior emargination, to a comparatively slender process extending backwards and gradually diminishing to an obtuse point, well shown in the detached ilia of the Maidstone *Iguanodon*, but here broken off. The chord of the acetabular arc or concavity, in Mr. Saull's specimen, measured 8 inches.

In the Maidstone *Iguanodon* the left ilium lies detached, with its symphysial articulation or inner surface uppermost, indicating by the extent of that surface, which equals the antero-posterior diameter of nearly five of the dorsal vertebræ of the same individual, the length of the sacrum peculiar to this and other Dinosaurian reptiles. Its slender posterior portion terminates in a subacute point: the anterior extremity of the right ischium, which has the opposite surface exposed, bends slightly outwards in the form of a thick tuberosity.

	In.	Lin.
The length of this bone is	16	0
Its depth	5	0
From the anterior tuberosity to the posterior angle of the acetabulum	8	0

Pubis.—This bone, which presents a simple spatulate form in the Crocodiles, already begins to increase in breadth at its symphysial extremity in the extinct family with concave vertebræ; and in the larger existing species of Lizards is expanded at both extremities, and has a very marked and recog-

* This bone is figured in Dr. Mantell's Memoir, Phil. Trans. 1841, pl. viii. fig. 28.

nizable character superadded, in being bent outwards with a considerable curvature.

A massive fragment of a broad osseous plate, bearing a segment of a large articular cavity at its thickest margin, and thence extended as a thinner plate, bent with a bold curvature, and terminated by a thick rounded labrum, offers characters of the Lacertian type of the pubis too obvious to be mistaken. This specimen is from the Tilgate strata; and, since the modifications of the ilium of the *Iguanodon* in the Maidstone skeleton approximate to the Lacertian type of the bone, and especially as manifested by the great *Varani*, in which the recurved character of the pubic plate is most strongly marked, we may, with much probability, assign the fossil in question to the pelvis of the *Iguanodon*.

This fine portion of pubis is of an inequilateral triangular form, 16 inches in its longest diameter, 9 inches 6 lines across its base or broadest part, 6 inches 8 lines across its narrowest part. The fractured surface of the bone, near the acetabulum, is 3 inches 3 lines thick. The acetabular depression is 7 inches across, a proportion which corresponds with that of the acetabular concavity in the ilium, and with the size of the cavity in which the head of the Iguanodon's femur must have been received. One angle of the cavity, corresponding with the anterior one in the *Varanus*, is raised; a broad and low obtuse ridge bounds the rest of the free margin of the cavity. The smooth labrum exchanges its character near one of the fractured edges of the bone for a rough surface, which indicates the commencement of the symphysis. In the apparent absence of the perforation below the acetabular depression, the present bone agrees with the Crocodilian type.

Ischium.—A second fragment of a large lamelliform bone (No. $\frac{188}{2188}$, Mantellian Catalogue) presents, in its general form and slightly twisted character, most resemblance to the ischium, with traceable modifications intermediate to those presented by the extinct *Goniopholis* and modern *Varani* and *Iguanæ*. The loss of the acetabular extremity, which is broken away, prevents a certain determination of this bone; the only natural dimension that can be taken is the circumference of the neck, or contracted portion between the acetabular end and the expanded symphysial plate: this circumference gives 7 inches. The slight twist of the bone upon this part as it expands to form the broad symphysial plate,—a character which is well marked in the ischium of the *Goniopholis*,—gives it a superficial resemblance to the humerus of some of the large Mammalia; but the bone is too short in proportion to the breadth indicated by the fractured symphysial end, to afford a probability of its having been the humerus of a land reptile, and much less of the *Iguanodon*, in which the form of the femur is well ascertained; unless, indeed, there be actually more discrepancy between the femur and humerus in size and form in the Dinosaurs, than has, hitherto, been recognized in the Reptilian Class.

Femur.—The Maidstone *Iguanodon* does not satisfactorily determine the question of the principal bone of the fore and hind extremities, for whilst the clavicles, many anterior dorsal vertebræ and anterior ribs, would lead one to suppose that the two long bones found in their proximity might be humeri; on the other hand the presence of the iliac bones, with some caudal vertebræ in the same slab, give equal probability to their being femora. The bones in question (1 and 2 in the figure of the Maidstone *Iguanodon*, published by Dr. Mantell in his 'Wonders of Geology,' vol. i. pl. ii.) have the same general characters, viz. the flattened trochanter at the proximal end, the compressed ridge-like process at the middle, and the two condyles with the deep and narrow fissure at the distal end, which are presented by the larger detached bones, described by Dr. Mantell as femora, from the Tilgate strata. They are other-

wise too much crushed and buried to yield materials for more minute comparison: each of these bones measures 33 inches in length.

In five separate long bones, having the general characters of the two above-mentioned in the Maidstone *Iguanodon*, numbered consecutively and marked 'Femur' in the Mantellian Collection, Nos. 1 and 3 differ from Nos. 4 and 5 in the greater inward production of the head, making the concavity of the line descending from the head to the median internal ridge somewhat deeper. The lower angle of this median ridge is more produced in Nos. 1, 2 and 3, than in Nos. 4 and 5. The whole inner contour is more regularly concave in No. 5, than in Nos. 1 or 3. Of these five bones, No. 2 was found associated with a tibia and fibula; and if, therefore, the differences above indicated should be more than mere individual varieties of the same bone, we might conclude Nos. 4 and 5 to be humeri. Such conclusion appears more probable from the circumstance of two of the longest and largest of the bones, having the general characters of the femur of the *Iguanodon*, which were obtained by Mr. Holmes from the quarry of the Wealden stone at Horsham, belonging both to the right side.

Now the other bones obtained in proximity with the above were all parts of one large individual, and it is much more probable, therefore, that we have here a right humerus and femur of the same individual, than two right femora of different individuals. One of the differences noticed in the Tilgate specimens, viz. the degree of obliquity at which the neck joins the shaft, is discernible in these; and close to that bone, which shows the characters that we have supposed to belong to the femur, were found bones corresponding with the tibia and fibula.

Regarding then this as the femur, it presents the following characters:—it measures 3 feet in length: its circumference at the middle of the shaft is 18 inches: the contour of the rounded inward-projecting part of head is $17\frac{1}{2}$ inches: two flat longitudinal facets meet near the middle of the anterior surface of the shaft at a rough and slightly elevated angle, which runs straight down to within thirteen inches of the distal end: the ridge there inclines towards the internal condyle and subsides. Two strong *vasti internus et externus* muscles are indicated by this ridge. The head of the bone is carried inwards, overhanging the shaft in a greater degree than the corresponding part does in the humerus. The line of the inner side of the shaft describes a graceful sinuous curve, being first concave, then slightly convex at the middle, where there is an indication of the projecting ridge which has been broken off: below this it is concave to the flattened antero-posteriorly extended, slightly concave surface, which descends vertically to the articular surface of the condyle, which surface proceeds horizontally at nearly a right angle with the line of the shaft of the bone. The antero-posterior extent of the flattened condyle is 8 inches. The thickness of the external wall of the shaft varies from half an inch to an inch.

Both ends of this fine bone are crushed and mutilated.

By the side of the femur were found two other bones, the largest of which corresponds with the tibia. The external part of the head is considerably produced horizontally; the circumference of the proximal articular surface is 30 inches. The longitudinally finely striated vertical surface of the shaft of the bone commences at the anterior part of the proximal end along a well-defined curved line, which runs transversely across the bone, convex downwards in the middle and concave downwards at each end: the bone rapidly contracts, and assumes, about 8 inches below the head, the subquadrilateral form; it is broadest from side to side: its circumference is here 15 inches. The anterior surface is flattened; the outer or radial side convex or rounded: the dense ex-

ternal walls of this bone are very thick, at least 1 inch. The length of this bone is 27 inches, but it wants the distal end. The proximal articulation is very convex from behind forwards, but, at the middle, it is slightly concave from side to side.

	In.	Lines.
Its lateral diameter is	12	0
Its antero-posterior diameter is	5	6

The disparity of size between the tibia and fibula is considerable, but the disparity in the thickness of the two extremities of the bone is less than in the bone which is described and figured as the fibula by Dr. Mantell. On the middle of one of the flat sides of the fibula is an oblong rough surface slightly raised, measuring 3 inches by 2 inches. The articular extremities of the fibula are tuberculate; the larger end is 4 inches across, the smaller one 3 inches across. The shaft is subcompressed.

A few yards from the three preceding bones was found the, presumed, humerus, which measured 35 inches in length, being very nearly equal in size with the femur. Its proximal extremity is crushed and mutilated: the shaft is compressed from before backwards; concave behind: the submedian ridge or compressed process is developed from the inner side of the shaft at the usual situation, and corresponds in form with those of the bones Nos. 4 and 5, Mantellian Collection. The distal condyles are divided anteriorly by a narrow longitudinal furrow, which penetrates deeply between them. As the absence of the deep fissure between the condyles of the femur is repeated in the humerus of the Iguana, so may its presence be repeated in the humerus of the *Iguanodon*.

The inner condyle projects backwards beyond the outer one, which is distinguished by being traversed by a longitudinal groove. This bone differs from the femur in the shorter neck supporting the head, in its more prominent median process, and in the uniform though slight concavity of the inner margin of the shaft.

The preceding observations were made during an inspection of the fossils in Mr. Holmes's interesting collection in the summer of 1840. I have subsequently been favoured by a letter from that gentleman, containing the following clear and valuable observations on the two large bones in his collection, which support the view I had taken of their nature.

"I have also examined the two large bones concerning which so much doubt exists. They both appear to belong to right extremities, but as the one which has the trochanter, and which by way of distinction I shall call No. 1 (humerus?), is so much crushed in the direction of the rough ridge, so strongly marked in the other, I cannot say with any degree of certainty whether it possessed the same form or not. There is, however, this difference at any rate. The head of No. 1 is so much mutilated that little can be said about it, but it is very clear that the neck is shorter than that of No. 2 (femur?), and there is a variation of nearly one-half in the degree of obliquity from the perpendicular of the shaft of the bone in which the two heads are set on; that of No. 2 being more so than the other. They also differ in another respect. In measuring from the inferior part of the head, supposing both bones to be placed in an erect position, to the superior portion of the condyle, which is the best way in which I can ascertain their relative length; No. 2 is longer in the shaft than the other bones, which, if they both belonged to the same individual, (and I think there is no sufficient reason to doubt it) would, according to thy conjecture, make it appear that one is the femur and the other the humerus.

"The question next arises as to which of the bones either name is to be appropriated. No. 1 has the trochanter, which is very similar in shape to the femur marked No. 5 in the British Museum. No. 2 has none in its present

mutilated state, but on examining the posterior part of the shaft, where on the internal side one might expect to meet with some remains of the base of the trochanter, I find the surface of the bone concave, and it diverges much more than I should suppose it would do if it had merely been continuous with the returning surface from the anterior part of the bone, if there had been no trochanter interposed to disturb the otherwise greater rotundity of the shape.

"This leads me to suppose that it once had one, and that it probably might have been formed like that in Nos. 1 and 2 in the British Museum. If they were not the bones of distinct animals, this might perhaps have been the case." Dated Horsham, Nov. 2nd, 1841.

The characters of the articular extremities of the femur which are obscured by the mutilated condition of the large specimen, are beautifully shown in the femur of a young *Iguanodon*, obtained from a pit near Rusper, four miles north of Horsham. The rounded portion of the head extends inwards; it is indented at its anterior part by the commencement of a longitudinal broad channel, which extends down upon the shaft: the articular surface is not confined to the inwardly produced head, but extends over the whole proximal horizontal surface of the femur, expanding as it approaches the outer part of the head. The articular surface is circumscribed by a well-defined linear groove, which separates it from the longitudinal striated surface of the shaft of the bone. At the posterior and external angle of the articular proximal end of the bone, a longitudinal column, separated by a longitudinal groove from the main shaft of the bone, falls into that shaft a little lower down the distal end: here the shaft expands and becomes flattened from before backwards. The distal end is characterized by a deep and narrow anterior longitudinal groove, situated not quite in the middle, but nearer the internal condyle: there is a corresponding longitudinal groove on the posterior part of the distal end, which is wider than the anterior one, and in the middle of the bone, separating the two condyles, but inclining beneath, and, as it were, undermining the backward projecting part of the internal condyle; this is much more prominent than the external one, which is traversed or divided by a narrow longitudinal fissure. The articular surface is irregular and tuberculate.

	In.	Lines.
The lateral diameter of proximal end	2	8
The lateral diameter of distal end	3	0
Antero-posterior diameter of outer part of proximal end .	2	0
Antero-posterior diameter of outer part of internal condyle	2	3

The femur of the Iguana differs as widely from that of the *Iguanodon* as does that of the Monitor or any other Lacertian reptile. The forms of the head and trochanter of the femur of the Iguana are just the reverse of those in the *Iguanodon*. The head of the femur in the Iguana is flattened from side to side, and its upper convex surface is extended from before backwards, making no projection over the gentle concave line leading from its inner surface down to the inner condyle. In the *Iguanodon* the head is rounded and rather compressed from before backwards; and is produced, as in Mammals, over the inner side of the shaft.

In the Iguana the trochanter is compressed from before backwards, and is separated by a wide and shallow groove from the oppositely compressed head: in the *Iguanodon* the trochanter is singularly flattened from side to side, and is applied to the outer side of the thick neck, from which it is separated by a deep and narrow fissure. The Iguana has no submedian internal process, and its distal condyles are slightly divided by a shallow depression.

The circumference of the femur of the *Iguanodon* very nearly equals one-half its length: the circumference of the femur of the Iguana only equals one-

fourth its length: yet the femur of the *Iguanodon* equals the united length of eleven of its dorsal vertebræ, while that of the Iguana equals the united length of only six of its dorsal vertebræ.

The femora of the Iguana stand out, like those of most other Lacertians, at right angles with the vertical plane of the trunk, which is rather slung upon than supported by those bones: but it is evident from the superior relative length and strength of those bones in the *Iguanodon*, from the different conformation of the articular, especially the proximal extremities, and from the ridges and processes indicative of the powerful muscles inserted into the bone, that it must have sustained the weight of the body in a manner more nearly resembling that in the pachydermal Mammalia. As in some of the more bulky of these quadrupeds, the indication of the 'ligamentum teres' is wanting in the head of the femur of the *Iguanodon*.

The tibia of the *Iguanodon* equals the united length of nine of the dorsal vertebræ, while in the Iguana it does not exceed the united length of five dorsal vertebræ, although it more nearly equals the femur in length than in the *Iguanodon*. The head of the tibia is more expanded and complicated by deep and wide grooves in the *Iguanodon*: the fibula is less expanded towards the distal end and less flattened against the tibia in the *Iguanodon*.

The fibula of the small *Iguanodon* from the pit at Rusper, equals the antero-posterior extent of the spines of eight dorsal vertebræ of the same individual. This bone is 13 inches long, 2 inches across the proximal end, and 6 lines across the distal end.

Of the great *Iguanodon* from the Horsham quarry two metacarpal or metatarsal bones are preserved in natural juxtaposition: one exceeds the other by four inches, and measures 2 feet 6 inches; the breadth of its distal end is 3 inches 3 lines; the shaft is compressed and subtrihedral; its texture is spongy at the centre. The proximal end is expanded, with a nearly flat articular surface, the contour of which is broken by two longitudinal indentations: the distal end offers a well-sculptured trochlear articulation for the first phalanx. The bone of the Maidstone *Iguanodon* (marked 7 in the figure above cited in the 'Wonders of Geology') corresponds with the above described bones of the foot.

Some of the phalanges, probably the middle ones, appear to have been singularly abbreviated; but they have not yet been discovered in such juxtaposition with undoubted Iguanodon's bones as to justify a more precise description of their characters under the present head.

The distal or ungual phalanges of the *Iguanodon*, although doubtless offering certain modifications of form in different toes, are shown by those preserved in the Maidstone *Iguanodon*, and others of much larger dimensions, found associated with the bones of the great *Iguanodon* of the Horsham quarry, to have had a less incurved, broader and more depressed form than in other known Saurians. Two of the largest ungual phalanges of the Horsham *Iguanodon* in Mr. Holmes's collection, are broad, subdepressed, with the curved vascular groove on each side, as in most other Saurians, with a slightly concave articular base, and terminating forwards in a round blunt edge; the outer boundary of the lateral grooves forms, at the posterior end of the groove, a laterally projecting process, rendering this part of the phalanx broader than the articular extremity or basis. The following are dimensions of the largest of the two phalanges:—

	In.	Lines.
Length	5	4
Breadth	3	2
Breadth at articular end	3	0
Depth at articular end	2	3

The last dimension gradually diminishes to the distal end.

This phalanx is slightly bent downwards; the under surface being concave longitudinally, but convex from side to side; less so than on the upper surface. The under surface is rough; the upper surface nearly smooth, except at the margin of the articular surface, on the projecting sides and at the distal extremity, which is sculptured by irregular vascular grooves and holes. The phalanx has a slight oblique twist to one side, and is somewhat thinned off to that side on which the curved groove is longer than on the other side.

In Mr. Saull's museum is an ungual phalanx of an *Iguanodon*, which nearly equals those from Horsham, and presents the same subdepressed form. The base is slightly convex transversely; more concave vertically: the articular surface is faintly divided by a median vertical rising: the rounded edge of the articular surface is slightly raised, interrupted on both sides by the smooth shallow commencement of the curved vascular groove: this deepens and contracts as it extends forwards. The upper surface is convex longitudinally and transversely; the lower surface is rather more convex transversely than the upper, but is slightly concave longitudinally. The upper and lateral surfaces, for about an inch near the base, are deeply sculptured by large irregular longitudinal grooves and ridges; the rest of the upper surface is impressed by fine interrupted longitudinal impressions; but having, on the whole, a smooth appearance. The laminated superposition of the exterior compact portion of the bone is shown by the separation of portions of the layers of about one line in thickness. The under surface is more deeply impressed by cavities having reticulate elevations. The right aliform process begins 10 lines from the articular surface, the left about 14 lines from the same part: their base is bounded below by slight impressions, and above by the lateral canals, which appear to sink into the bone. A few distant vascular grooves mark the upper surface of the bone, but more numerous larger ones are situated near the lateral canals and at the broken anterior end of the phalanx. The following are the dimensions of this bone:—

	In.	Lines.
Transverse diameter	3	5
Transverse diameter of broken end	2	2
Vertical diameter of base	2	7
Vertical diameter of broken end	1	6
Length to broken end	4	4

it was probably more than 5 inches long when entire.

The largest of the phalangeal bones in the collection of Wealden Reptiles in the British Museum, which from its breadth, slight degree of obliquity and vascular canals is referrible to the *Iguanodon*, is less than those just described. The phalanx in question (No. $\frac{384}{2384}$, Mantellian Collection) is conical, $4\frac{1}{2}$ inches long, probably 5 inches when entire; but the apex is broken off: the longest diameter of the base or articular surface is 3 inches 3 lines: it is slightly and obliquely compressed, and very slightly curved, and from this circumstance, as well as from the obliquity of the base and its unsymmetrical figure, it probably belonged to the small outer or inner toe at the margin of the foot. Only a small part of the natural smooth articular surface is left, the rest appears to have been scraped away, so that the coarse cancellous structure of the middle of the bone is exposed. The free surface of the bone near the base is deeply sculptured by irregular longitudinal furrows, which served for the implantation of the articular ligaments. The rest of the free surface is tolerably smooth, except at the sides near the apex, where there are numerous oblique outlets for the large vessels and nerves supplying the secreting organ of the claw. The two lateral longitudinal curved grooves which characterize the claws of most Saurians are here well developed; they commence, one at, the other near, the base; are at first shallow, then deepen, and finally sink into

the substance of the bone about $1\frac{1}{2}$ inch from its fractured apex. Below one of these canals there is a shallow smooth impression, corresponding no doubt with the margin of the claw. The under surface of the phalanx indicated by the concavity of the curved grooves is more convex transversely than the upper surface: the distance between the converging lateral grooves in this surface is one inch.

Among the few other phalangeal bones from Dr. Mantell's collection in the British Museum, there is one (figured in the 'Wonders of Geology,' pl. iii. fig. 1, as belonging to the fore-foot of the *Iguanodon*) which differs in a marked manner from the specimens just described, being as much compressed from side to side as the Iguanodon's ungual phalanges are, for the most part, flattened from above downwards. One of these compressed phalanges must have been at least four inches in length; it now measures three inches, with the extremity broken off; it is 2 inches 8 lines in vertical diameter at the base, and only 1 inch 2 lines in the greatest transverse diameter. The phalanx is more curved downwards than any of the true Iguanodon's phalanges, and it is traversed by a longer and shallower groove, the lower margin of which is not produced into a lateral aliform process, nor does the distal end of the groove sink into the substance of the bone.

The ungual phalanges on both the fore and hind feet of the Iguana resemble this phalanx in form more than they do those of the *Iguanodon*. In the fore-foot of the Crocodile the ungual phalanx of the first or innermost toe is broad and flat, with lateral ridges, much resembling the depressed phalanges of the *Iguanodon*. The ungual phalanx of the third digit is of the same length, but is thinner in both transverse and vertical directions, but is less so in the latter. It is not more curved. Still the difference (and this is the greatest that I can perceive in comparing the different ungual phalanges of the same individual Crocodile (*Croc. acutus*)) is much less than that which is manifested between the depressed and the compressed phalanges hitherto referred to the *Iguanodon*. In the great proportion of the skeleton found near Maidstone are two phalanges which correspond in form with those enormous specimens found near Horsham, and with the small depressed claw-bones from Tilgate Forest, unquestionably belonging to the *Iguanodon*, and supposed by Dr. Mantell to be peculiar to the hind-foot of that Saurian.

Size of the Iguanodon.—From the comparison, which the few connected portions of the skeleton of the *Iguanodon* enable us to make, between the bones of the extremities and the vertebral column, it is evident that the hind-legs at least, and probably also the fore-legs, were longer and stronger in proportion to the trunk than in any existing Saurian. One can scarcely suppress a feeling of surprise, that this striking characteristic of the *Iguanodon*, in common with other *Dinosauria*, should have been, hitherto, overlooked; since the required evidence is only an associated vertebra and long bone of the same individual, or a comparison of the largest detached vertebræ with the longest femora or humeri. This characteristic is, nevertheless, one of the most important towards a restoration of the extinct reptile, since an approximation to a true conception of the size of the entire animal could only be made after the general proportions of the body to the extremities had been ascertained.

But it is very obvious that the exaggerated resemblances of the *Iguanodon* to the Iguana have misled the Palæontologists who have hitherto published the results of their calculations of the size of the *Iguanodon*; and, hence, the dimensions of 100 feet in length arrived at by a comparison of the teeth and clavicle of the *Iguanodon* with the *Iguana*, of 75 feet from a similar comparison of their femora, and of 80 feet from that of the claw-bone, which, if founded upon the largest specimen from Horsham, instead of the one com-

pared by Dr. Mantell*, would yield a result of upwards of 200 feet for the total length of the *Iguanodon*, since the Horsham phalanx exceeds the size of the largest of the recent Iguana's phalanges by 40 times!

But the same reasons which have been assigned for calculating the bulk of the *Megalosaurus* on the basis of the vertebræ, apply with equal force to the *Iguanodon*. Now the largest vertebra of an *Iguanodon* which has yet been obtained does not, as has been before stated, exceed $4\frac{1}{2}$ inches in length; the most common size being 4 inches. The intervertebral substance is shown, by the naturally juxtaposed series of dorsal vertebræ in the Maidstone *Iguanodon*, to be not more than one-third of an inch in thickness. All the accurately determined vertebræ of the *Iguanodon* manifest the same constancy of their antero-posterior diameter which prevails in Saurians generally; the discovery of the true character of the supposed Lacertian vertebræ, six inches in length, removes the only remaining doubt that could have attached itself to this important element in the present calculation†. The cervical vertebræ of the *Iguanodon*, when discovered, if they prove to differ in length from the known dorsal and caudal vertebræ, will be, in all probability, somewhat shorter, as they are in the Hylæosaur and in all known Crocodiles and Lizards. It remains, therefore, to discover the most probable number of the vertebræ of the *Iguanodon*, in order to apply their length individually to the estimate of the length of the entire body. The structure of the vertebræ and the ribs, and especially the variation in both structure and size which the ribs of the *Iguanodon*, already obtained, demonstrate to have prevailed in the costal series, render it much more probable that the number of the costal vertebræ would resemble that of the Crocodiles than that of the *Scincus* or other Lizards with unusually numerous dorsal vertebræ, and which possess ribs of a simple and uniform structure, and of nearly equal size. The most probable number of vertebræ of the trunk, from the atlas to the last lumbar inclusive, calculated from Crocodilian analogies, would be 24 vertebræ; which is also the number possessed by the Iguana.

Twenty-four vertebræ, estimated with their intervertebral spaces at 5 inches each, give 10 feet; if to this we add the length of the sacrum, viz. 17 inches, then that of the trunk of the *Iguanodon* would be 11 feet 5 inches; which exceeds that of the Megatherium. If there be any part of the skeleton of the Iguana which may with greater probability than the rest be supposed to have the proportions of the corresponding part of the *Iguanodon*, it is the lower jaw, by virtue of the analogy of the teeth and the substances they are adapted to prepare for digestion. Now the lower jaw gives the length of the head in the Iguana, and this equals the length of six dorsal vertebræ, so that as 5 inches rather exceeds the length of the largest Iguanodon's vertebra yet obtained, with the intervertebral space superadded, on this calculation the length of the head of the largest *Iguanodon* must have been 2 feet 6 inches. In the description of the caudal vertebræ it has been shown that the *Iguanodon* could as little have resembled the Iguana in the length of its tail‡, as in the anatomical characters of any of the constituent vertebræ of that part: the changes which the series of six caudal vertebræ present in the length and form of the spinous processes, and in the place of origin of the transverse processes, indicate the tail to have been shorter in the *Iguanodon* than in the Crocodile. Assuming, however, that the number of caudal vertebræ of the *Iguanodon* equalled that in the Crocodile, and allowing to each vertebra with its inter-

* Mantell, Geology of the South-east of England, p. 314.

† See p. 92 of the present Report.

‡ See also the judicious remarks by Dr. Buckland to the same effect, Bridgewater Treatise, p. 244.

vertebral space $4\frac{1}{2}$ inches, we obtain the length of 12 feet 6 inches for the tail of the *Iguanodon*. On the foregoing data, therefore, we may liberally assign the following dimensions to the *Iguanodon*:—

	Feet.
Length of head, say	3
Length of trunk with sacrum	12
Length of tail	13
Total length of the *Iguanodon* . . .	28

The same observations on the general form and proportions of the animal, and its approximation in this respect to the Mammalia, especially the great extinct Megatherioid or Pachydermal species, apply as well to the *Iguanodon* as to the *Megalosaurus*.

Order LACERTILIA.

Leaving now the gigantic Saurians constituting the order *Dinosauria*, above characterized, and establishing in several important points of their osteological structure the transition from the Crocodilian to the Lacertian order, I next proceed to notice the remains of those extinct Reptiles, which manifest in the enduring parts of their organization a closer affinity to the extensive and varied order of the smaller and lower organized Saurians which are distributed over all the warmer parts of the present surface of the earth.

The ancient representatives of the Lacertian order are for the most part of gigantic size, and deviate, like many of the ancient Crocodilians, from existing Lizards, by very remarkable characters of the vertebræ, teeth, and dermal bones.

Genus Mosasaurus.

Commencing with the species which retain the ordinary ball and socket structure of the vertebræ, the gigantic *Mosasaurus* first claims attention. Two vertebræ which have the anterior articular facet concave, the posterior convex, and the other characters of this genus, are preserved in the Mantellian Collection. They are from the chalk formation in Sussex, and have been referred by Dr. Mantell to the genus *Mosasaurus*.

Genus Leiodon.

Hitherto no teeth corresponding with those of the *Mosasaurus Hoffmanni* of St. Peter's Mount near Maestricht, have been discovered in the chalk formations of England. The teeth of the Pliosaur have, in some instances, been mistaken for those of the Mosasaur.

The teeth from the chalk of Norfolk, figured and described in my 'Odontography*' as representatives of the genus *Leiodon*, make the nearest approach to the characters of those of the *Mosasaurus*. They are about one half the size of the maxillary teeth of the *Mosasaurus Hoffmanni*, and differ more essentially in having their outer side as convex as the inner side, the transverse section of the crown being elliptic, the pointed extremities of the ellipse corresponding with two opposite longitudinal trenchant ridges, which separate the outer from the inner side of the tooth. The crown expands at the base, which is circular, and is anchylosed to a conical process, developed from the broad alveolar margin of the jaw. In this, which is termed the "acrodont" type of dentition, the *Leiodon* corresponds with the *Mosasaur*. It is probable that the vertebræ of the two extinct reptiles may have corresponded in form; and it is possible that those from the English chalk, hitherto referred to the *Mosasaurus*, may appertain to the same species as the teeth here de-

* P. 261, pl. lxxii.

scribed. From the correspondence in the general structure, smooth external surface, and mode of attachment of the teeth between the Maestricht Mosasaur and the English Leiodon, it may be concluded that the latter reptile had the same affinity to the Lacertian type, which the Mosasaur so strikingly manifests in the presence of pterygoid teeth.

Genus Raphiosaurus.

Under this name I propose to notice a small and hitherto undescribed genus of Lacertians, from the chalk formations near Cambridge, indicated by a portion of the lower jaw, containing twenty-two close-set, awl-shaped teeth anchylosed by their bases to an outer alveolar parapet of bone, and thus corresponding with the pleurodont type of dentition among the Lizards.

To the same genus may belong a beautiful specimen in the museum of Sir Philip Egerton, consisting of a series of twenty dorsal, two lumbar, two sacral, and a few of the caudal vertebræ, with the pelvic bones, from the chalk near Maidstone, which correspond with the jaw of the *Raphiosaurus* in size. The vertebral characters are essentially those of the modern Lacertians; but the absence of extremities and teeth prevents the generic affinities being accurately determined.

It is interesting to find this second instance of the 'procœlian' type of vertebræ—or those with the anterior cup and posterior ball—in the chalk formations, below which I have not met with any instance of a Reptile agreeing with the existing species in this structure.

Pleurodont Eocene Lizard.—Among the fossils obtained by Mr. Colchester from the Eocene sand, underlying the Red Crag at Kyson, or Kingston, in Suffolk, the existence of a lizard, about the size of the Iguana, is indicated by a part of a lower jaw, armed with close-set, slender, subcylindrical, antero-posteriorly compressed teeth, attached to shallow alveoli, and with their bases protected by an external parapet of bone. The fragment of jaw is traversed by a longitudinal groove on the inside, and perforated, as in most modern lizards, by numerous vascular foramina along the outside. The teeth are hollow at their base.

Scincoid Oolite Lizard.—A small Lacertian is indicated by remains discovered in the celebrated oolite at Stonesfield. The most intelligible of these is a femur, ten lines in length, having a hemispherical head supported on a short subcompressed neck, on each side of the base of which there is a strong conical trochanterian process: the middle of the shaft is cylindrical, and soon expands to form a broad distal extremity. This shape of the bone proves it not to be the young of any of the great Saurians hitherto discovered at Stonesfield (the expansion of the distal end removes it from the Chelonian reptiles), but indicates its affinity to the Scincoidian lizards, the largest forms of which, it may be remarked, now exist in Australia, where they are associated with *Araucariæ* and cycadeous plants, with living *Terebratulæ*, and *Trigoniæ*, and with the peculiar marsupial quadrupeds; the remains of all which forms of organized beings characterize the same stratum and locality as that in which the present extinct Lacertian was found.

No vertebræ of the procœlian type have hitherto been discovered in the oolite, and it is most probable that those of the small Lacertian here indicated, agree with those of most other extinct Saurians of the secondary formations in having both articular extremities subconcave.

Genus Rhynchosaurus.

The biconcave structure unquestionably characterizes the vertebræ of the small Lacertian from the new red sandstone quarries near Shrewsbury, on which the well-marked and distinct genus *Rhynchosaurus* is founded.

For the opportunity of examining the rare and interesting remains of the *Rhynchosaurus* I am indebted to Dr. Ogier Ward of Shrewsbury, and to the Council of the Natural History Society of that town, in the museum of which many of the fossils here described are deposited.

They occur at the Grinsill quarries, in a fine-grained sandstone, and also in a coarse burr-sandstone; in the latter are imbedded some vertebræ, portions of the lower jaw, a nearly entire skull, fragments of the pelvis and of two femora: in the fine-grained sandstone, vertebræ, ribs, and some bones of the scapular and pelvic arches are imbedded. The bones present a very brittle and compact texture; the exposed surface is usually smooth, or very finely striated, and of a light blue colour. The sandstones containing these bones occasionally exhibit impressions of footsteps which resemble those figured in the Memoir by Messrs. Murchison and Strickland, Geol. Trans., 2nd Series, vol. v. pl. xxviii. fig. 1, but differ in the more distinct marks of the claws, the less distinct impression of a web, the more diminutive size of the innermost toe, and an impression corresponding with the hinder part of the foot, which Dr. Ward compares to "a hind-toe pointing backwards, that, like the hind-claw of some birds, only touched the ground with its point, which was armed in some of the foot-prints with a claw still longer than those of the fore-toes *." The foot-prints are likewise more equal in size and likewise in their intervals than those figured by Messrs. Murchison and Strickland: they measure from the extremity of the outermost or fifth toe to that of the innermost or first rudimental toe, about one inch and a half. They are the only foot-prints that have as yet been detected in the new red sandstone quarries at Grinsill.

I proceed now to describe the fossil bones, respecting which Dr. Ward observes, "as they have always been found nearly in the same bed as that impressed by the footsteps above described, I am induced to believe that these are the bones of the same animal:" an opinion, which, from the correspondence between the bones and the foot-prints in size, is, at least, highly probable.

Vertebræ.—Both surfaces of the centrum are concave, and are deeper than in the biconcave vertebræ of the extinct Crocodilians; the texture of the centrum is compact throughout. The two lateral surfaces join the under surface at a nearly right angle, the transverse section presenting a subquadrate form, with the angles rounded off: the under surface and sides are regularly concave longitudinally.

The neural arch is anchylosed with the centrum, without trace of suture, as in most lizards: it immediately expands and sends outwards from each angle of its base a broad triangular process with a flat articular surface; the two anterior surfaces look directly upwards, the posterior ones downwards; the latter are continued backwards beyond the posterior extremity of the centrum; the tubercle for the simple articulation of the rib is situated immediately beneath the anterior oblique process. So far the vertebræ of the *Rhynchosaurus*, always excepting their biconcave structure, resemble the vertebræ of most recent lizards. In the modification next to be noticed, they show one of the vertebral characters of the *Dinosauria*. A broad obtuse ridge rises from the upper convex surface of the posterior articular process and arches forwards along the neural arch above the anterior articular process, and gradually subsides anterior to its base: the upper part of this arched angular ridge forms, with that of the opposite side, a platform, from the middle line of which the spinous process is developed. This structure is not present in existing lizards; the sides of the neural arch in their vertebræ immediately converge from the articular processes to the base of the spine, without the intervention of an angular ridge formed by the side of a raised platform. The base of the spinous

* Extract of a letter, dated Shrewsbury, November 27th, 1840.

process in the Rhynchosaur is broadest behind, and commences there by two roots or ridges, one from the upper and back part of each posterior articular process: they meet at the posterior part of the summit of the neural arch, whence the spinous process is continued upwards as a simple plate of bone, its base extending forwards along about two-thirds of the length of the platform, which then again divides into two ridges, which diverge from each other in slight curves to the anterior and external angles of the neurapophyses. The interspace of the diverging anterior crura of the base of the spine is occupied by a triangular fossa, not continued into the substance of the spine; this fossa is bounded below by a horizontal plate of bone extended over the anterior part of the spinal canal, and terminated by a convex outline. The anterior margin of the spinous process is thin and trenchant; the height of the spine does not exceed the antero-posterior diameter of its base; it is obliquely rounded off. The spinal canal sinks into the middle part of the centrum and rises to the base of the spine, so that its vertical diameter is twice as great at the middle as at the two extremities: this modification resembles in a certain degree that of the vertebræ of the *Palæosaurus* from the Bristol conglomerate. The following are dimensions of the most perfect of the dorsal vertebræ of the *Rhynchosaurus*:—

	Lines.
The length of the centrum	$5\frac{1}{2}$
Height of the articular end	3
Breadth of the articular end	$2\frac{2}{3}\frac{1}{3}$
From the lower margin of the posterior extremity of the centrum to the posterior part of the base of the spine	5
From the lower margin of the posterior extremity of the centrum to the summit of the spine	9
Antero-posterior extent of base of spine	4
Breadth of the neural arch, from the outer margin of one anterior articular process to that of the opposite side	$8\frac{1}{2}$
Breadth of the neural arch at the interspace between the anterior and posterior oblique processes	4
Breadth of the neural arch across the middle of the spinal platform	2

Skull.—The most complete specimen yet obtained of this instructive part of the skeleton of the *Rhynchosaurus*, is imbedded in a portion of the coarse-grained sandstone from the Grinsill quarries. The lower jaw is in its natural position, as when the mouth is shut, showing that the parts had not been dislocated from the time of the death of the animal to its becoming imbedded in the sand.

The skull presents the form of a four-sided pyramid, compressed laterally, and with the upper facet arching down in a graceful curve to the apex, which is formed by the termination of the muzzle. The very narrow cranial box; the wide temporal fossæ on each side, bounded posteriorly by the parietal and the mastoid bones, and laterally by strong compressed zygomata; the long tympanic pedicle, descending freely and vertically from the point of union of the posterior transverse and zygomatic arches, and terminating in a convex pulley for the articular concavity of the lower jaw; the large and complete orbits; and the short, compressed, and bent down maxillæ,—all combine to prove the fossil to belong to the Lacertian division of the Saurian order. The mode of articulation of the skull with the spine cannot be determined in the present specimen, but the lateral compression and the depth of the skull, the great vertical breadth of the superior maxillary bone, the smaller relative size of the temporal spaces, the great vertical breadth of the lower jaw, all prove that it does not belong to a reptile of the Batrachian order. The shortness

of the muzzle and its compressed form, equally remove it from the Crocodilians. No Chelonian has the tympanic pedicle so long, so narrow, or so freely suspended to the posterior and lateral angles of the cranium.

The general aspect of the skull differs, however, from that of existing Lacertians, and resembles that of a bird or turtle, which resemblance is increased by the apparent absence of teeth. The intermaxillary bones, moreover, are double, as in Crocodiles and Chelonians, but, with this exception, all the essential characters of the structure of the skull are those of the Lizard.

Of the proper walls of the cerebral cavity, the portion formed by the parietal and frontal bones is exposed; the parietal is traversed longitudinally by a thin, but high, median crest; the part of the bone forming the sides of the small cerebral cavity are convex, and the breadth of the bone diminishes towards the occiput; here it divides into two branches, which pass outwards more transversely than in existing lizards. There is no perforation either in the parietal bone or in the coronal suture. At the anterior part of the parietal crest two lines diverge from each other at a right angle to the upper part of the orbit, and separate the post-frontals. A nearly transverse suture divides the fore-part of the parietal from the post-frontals. The median frontal bone is single, like that of the New World Monitors (*Thorictes*, *Tejus*, &c.) and the Iguanæ, and not divided, as in the Varanians. It expands slightly as it advances towards the fore-part of the orbits: the oblique lines dividing the median frontals from the post-frontals, and the supraorbital ridges are raised, so that the interspace is slightly concave, and the surface is also broken by irregular elevations and depressions. Each post-frontal is divided by a nearly transverse suture. The posterior frontal completes the upper and outer part of the orbit by a thin, well-defined, curved plate; an irregular obtuse ridge descends in a nearly vertical direction behind this plate, and then the posterior frontal contracts and is extended backwards in the form of a long compressed process, gradually terminating in a point, which overlaps the zygomatic bone. This bone forms the medium of union between the long posterior frontal and the mastoid.

The tympanic bone presents a slight sigmoid flexure, and is expanded transversely at its distal extremity; its posterior surface is exposed, which is convex and rounded, and continued externally in the form of a thin plate, which is concave behind. The thick convex stem divides near the lower end into two ridges, which diverge, like the condyles of a humerus, and intercept the trochlea, on which the concave articulation of the lower jaw plays. The tympanic trochlea is convex from behind forwards, concave from side to side. The orbit is large, nearly circular in form, and its bony frame is complete; this is formed above by the median, anterior, and posterior frontals; before by the anterior frontal and lachrymal; below by the malar; and behind by the malar and posterior frontal.

The malar bone, as in most lizards, is long, slender, and bent upon itself, but its external surface is unusually concave, the orbital plate bending outwards like the corresponding rim formed by the frontal bone. The anterior or horizontal branch of the malar gradually tapers to a point which is wedged in between the lachrymal and maxillary bones. The posterior branch ascends at nearly a right angle, and is applied obliquely to the posterior part of the descending process of the posterior frontal. At the angle between the two portions of the malar a process is continued backwards for about half an inch, but its extremity is broken off. The lachrymal bone presents the same relative position and size as in the *Thorictes*, *Lacerta*, and most lizards; a tubercle rises from about the middle of its external surface. The superior maxillary is a broad vertical triangular plate of bone, with a smooth external surface;

the alveolar border projects externally like a ridge, above which the bone is slightly concave. This ridge appears to be slightly dentated; it overlaps the corresponding alveolar border of the lower jaw. The posterior and superior margin of the maxillary is slightly concave, and joins the malar and lachrymal bones and a small part of the prefrontal: the anterior superior margin joins the upper half of the elongated intermaxillary, which divides it from the nasal bones and the external nostril; the lower side or base of the triangle, which forms the alveolar border, is convex.

The most singular character of the cranium of the present fossil genus is afforded by the intermaxillary bones. These, in their length and regular downward curvature, give to the fore-part of the skull the physiognomy of that of a parrot or accipitrine bird, but they differ essentially from both those of the bird and lizard in being distinct from each other throughout their whole length, and in gradually diminishing to their inferior extremity, which is not expanded and continued laterally to form any part of the alveolar border of the upper jaw. Each intermaxillary bone is a slender, subcompressed, elongated bone, bent so as to describe a quarter of a circle; the upper half is thinner, but rather broader than the lower half, and is wedged in between the superior maxillary, frontal and nasal bones; the lower half, which is somewhat narrower but thicker, and is subcylindrical, *projects freely downwards beyond the superior maxillary bone*; the deep anterior extremity or compressed symphysis of the lower jaw is applied to the posterior surface of these produced extremities of the two intermaxillaries, when the mouth is closed. The two intermaxillaries converge towards each other from their posterior origins, and are in close contact with each other, where they form the singular curved projecting beak.

The external nostril is single and situated between the upper diverging ends of the intermaxillaries, but a fracture of the fossil at this part prevents the precise form of this aperture, or the mode of termination of the nasal bones, from being determined. The nasal bones, if not actually absent in the present fossil, as in most Chelonians, must have been extremely small, as in the Chameleons.

The lower jaw is of considerable depth, and exceeds, as in most Saurians, the length of the cranium. The articular cavity is deep and wide; the angle of the jaw is broken off directly behind this cavity on the left side, but is continued backwards beyond it for more than half an inch on the right side. The ramus gradually expands in the vertical direction, and becomes thinner from side to side, as it advances forwards to about its middle part, which is just behind the orbit, where it measures 11 lines in depth; it then begins gradually to diminish vertically to the symphysis, which again slightly increases vertically to its termination, which is obliquely truncated, much compressed laterally, and applied against the deflected extremities of the produced intermaxillaries. The posterior half of the maxillary ramus is slightly convex externally, the anterior narrower part is slightly concave; the superior margin describes a slight but graceful sigmoid curve, convex posteriorly, and concave anteriorly, where it is applied to the convex alveolar border of the upper maxillary bone, to the inner side of which it is closely adapted. The alveolar border forms an external, convex, projecting ridge, analogous to that of the upper jaw. The composite structure of the lower jaw is very clearly displayed in the fossil. The articular piece is short, but is continued forward as a slender process below the angular piece, as in the *Varanus*; the angular piece is relatively larger than in the *Varanus*, and presents nearly the same proportions as in the *Thorictes*. The supra-angular is larger, and occupies the proportion of the jaw formed by the supra-angular and coronoid elements

in *Thorictes* and other lizards: the opercular element extends further upon the outside of the jaw from its lower margin than in the existing lizards; the *Thorictes* again, in this respect, coming nearest to the *Rhynchosaurus*: the dentary element constitutes the rest of the outer part of the ramus, but not the slightest trace of teeth is discernible.

The present singular and highly interesting cranium seems to have been preserved with the mouth in the naturally closed state, and the upper and lower jaws are in close contact. In this state we must suppose that they were originally buried in the sandy matrix which afterwards hardened around them; and since lizards, owing to the unlimited reproduction of their teeth, do not become edentulous by age, we must conclude that the state in which the *Rhynchosaurus* was buried, with its lower jaw in undisturbed articulation with the head, accorded with its natural condition, while living, so far as the less perishable hard parts of its masticatory organs were concerned. Nevertheless, since a view of the inner side of the alveolar border of the jaws has not been obtained, we cannot be assured of the actual edentulous character of this very singular Saurian; for in the genera *Agama* and *Chameleo* the dental system, seen only from the outside of the jaws, is represented by mere dentations of the alveolar border, and the anchylosed bases of the teeth, the crowns of which really form the dentations, are recognizable only by an inside view. The indications of the dental system are at any rate more obscure in the *Rhynchosaurus* than in any existing Lacertian; the dentations of the upper jaw are absolutely feebler than in the Chameleon, and no trace of them can be detected in the lower jaw, where they are strongest in the Chameleon. The absence of the coronoid process in the *Rhynchosaurus*, which is conspicuously developed in all existing lizards, corresponds with the unarmed condition of the jaw, and the resemblance of the *Rhynchosaurus* in this respect to the *Testudo* (*Chelys*) *ferox*, would seem to indicate that the correspondence extended to the toothless condition of the jaws. The resemblance of the mouth to the compressed beak of certain sea-birds, the bending down of the curved and elongated intermaxillaries, so as to be opposed to the deep symphysial extremity of the lower jaw, are further indications that the ancient Rhynchosaur may have had its jaws encased by a bony sheath, as in birds and turtles.

A small flattened triangular plate, which adhered to the posterior part of the skull, was suspected by Dr. Ward to be a tooth; it appeared to me, from the character of the exposed surface, to have at least equal claims to be regarded as a dermal scute. In preparing the mould of the cranium this part was detached and lost, a circumstance which I have much regretted, since it prevented my applying to it the test of a microscopical examination.

I proceed now briefly to notice the other portions of the skeleton, which, from their size, texture, and community of stratum and locality, are with much probability referable to the *Rhynchosaurus*.

Considerable portions of two rami of two distinct lower jaws, in portions of sandstone from the Grinsill quarries, show the same structure as that of the jaw in the cranium above described; the thick edentulous alveolar border is bounded below on the outside by the longitudinal channel; the lower border of the ramus is thick and smoothly rounded, it is somewhat abruptly constricted immediately behind the deflected extremity or symphysis. The structure of the bone is very compact; the fractured end demonstrates the large cavity, common in reptiles, which is included between the opercular and dentary pieces.

One piece of fine-grained sandstone contains a considerable proportion of four of the dorsal vertebræ in a connected chain, which measures 1 inch 10

lines. Near this chain of four and a smaller part of a fifth vertebra, there are portions of four ribs. These have a single, not a bifurcated head; they are subcompressed, slightly and pretty uniformly curved, and grooved longitudinally on both sides; the longest portion of rib measures 2 inches, following the curvature. The same fragment of sandstone contains three flat bones, which offer several striking modifications, whether they be compared with the constituents of an os innominatum or of the scapular arch.

The most entire of the three bones consists of a thicker articular end; a long, broad and thin plate, forming the body of the bone; and a moderately long trihedral process, given off from the convex margin near the articular end. In these characters the comparative anatomist conversant with the modifications of the skeleton in recent and extinct Saurians will recognize a resemblance to the scapula of the Iguanodon and Hylæosaur, in a minor degree to the ischium of the Crocodile, and somewhat more remotely, to the pubis of the Tortoise. The trihedral process, in the second comparison, would match the anterior pubic process of the Crocodile's ischium, but the entire bone would differ from that of the Crocodile in the slenderness of the pubic process, in the greater breadth and less length of the body of the bone, and in its extreme thinness; it increases in thickness, however, as in the Crocodile's ischium, towards the articular end. The correspondence of the trihedral process of the bone in question with the long spinous process of the Chelonian pubis, is less close than the one just discussed. If the present well-marked bone of the Rhynchosaur be regarded as a scapula, it is to that bone in the *Dinosauria* that it offers most resemblance; and the prismatic process would then correspond with the one sent off from the anterior part of the coracoid articular surface in the scapula of the Hylæosaur and Iguanodon. It is the concavity at the neck of the bone, at the side opposite that from which the process is sent, which gives it a nearer resemblance to the Dinosaurian scapula than to the Crocodilian ischium; it differs from the scapula of the Crocodile in having the posterior margin, beyond the neck, straight instead of convex; the corresponding margin in the ischium being concave. The blade of the bone, considered as scapula, is broader and shorter than in either the Dinosaurs or Crocodiles. Its outer surface is slightly convex: supposing it to be placed vertically upon the thicker articular end, the prismatic process is directed forwards and downwards. There are a few small pits or inequalities near the neck or thick articular margin in the present fossil. The outer surface of the plate is marked with extremely fine striæ, radiating from the neck.

	In.	Lin.
Length of the bone	1	8
Breadth of neck	0	$5\frac{1}{2}$
Breadth of base	1	0
Length of trihedral process	0	8

Coracoid.—The remains of a thin and broad plate of bone, attached by a short neck to an apparently articular thickened head or process, might be compared with a coracoid, as it resembles, so far as it is preserved, the coracoid of lizards, more than it does any other known bone; there is not, however, the perforation near the articular surface. The breadth of the neck is 6 lines, that of the body of the bone which remains 13 lines; the length, or diameter at right angles to the above, is 10 lines; the bone is thinned off to an edge, which is gently convex.

Humerus.—A third bone, imbedded in the same piece of sandstone at a little distance from the preceding, is expanded at both extremities, contracted and twisted in the middle; one of the expanded extremities, apparently the

proximal end, is nearly entire; it terminates by an irregular convex border, not thinned off to an edge, but adapted to the formation of a joint, and to the attachment of cartilage. The exposed surface of the expanded head is concave from side to side., somewhat resembling the expanded and bent pubic plate in lizards. The opposite extremity is broken across; it shows the commencement of a slight longitudinal ridge near its middle part. This bone bears most resemblance to a humerus, but I am at present unable to determine it unequivocally. If compared with the left pubis of Lacertians, the entire and bent extremity corresponds with the median portion of that bone; but the middle part or stem is much longer in the fossil, and the broken end, which would agree with the acetabular end of the pubis, is too thin to have entered into the formation of such a cavity in the fossil; it likewise wants the perforation which characterizes the pubis in lizards. The same thinness and imperforate condition of the fractured end oppose the comparison of the present bone with the coracoid of the Crocodile.

	In.	Lin.
Length of this bone as far as complete	1	9
Breadth of middle	0	3
Breadth of entire expanded extremity	0	10

In the slab containing the above-described bones, there are other fragments of bone, but too small and imperfect for profitable description. Those of which I have endeavoured to make the form and analogies intelligible, though evidently peculiar, as might be expected in a Saurian with so strange a head, and perhaps with a hind-toe directed backwards as in birds, may be regarded as, most probably, constituents of a strong and well-developed pectoral arch, and a humerus; and they indubitably indicate a mechanism for locomotion on land, which would well agree with that of the animal that has left the impressions of its footsteps upon the same sandstone.

Radius and Ulna.—Another piece of coarse-grained sandstone from the same quarry contains a series of seven or eight vertebræ in a very fragmentary state, also two or three ribs, rather more slender and not so distinctly grooved as in the fine-grained slab, and the proximal extremities of two long bones, which may be best compared with the radius and ulna. The shaft of the radius is more slender than that of the ulna; one side is flat, the other convex; it expands and assumes a subtrihedral figure, by the development of a slight longitudinal ridge; its proximal end is compressed and more suddenly expanded; its breadth is $2\frac{1}{4}$ lines, that of the shaft of the bone is 1 line. The impression, partly broken away in the stone, indicates the greater expansion of the distal end of this bone, with a length of 1 inch 3 lines. The proximal end of the ulna has a distinct trihedral figure, and the expanded extremity is produced backwards, so as to indicate the olecranon; the breadth of the head is 4 lines, that of the middle of the shaft is $2\frac{1}{2}$ lines. There is a portion of a broad and flat bone in this piece which may have belonged to the scapular arch.

Ilium.—In another piece of stone, with the other portion of the same chain of five vertebræ, there is a broad and flat bone, apparently terminating in a long narrow process at one end, which may be an ilium; its length is indicated to be at least 1 inch 7 lines.

Femora.—A thin piece of burr or coarse-grained sandstone contains the articular end of a broad and flat bone, in which the raised oblong surface of the joint is divided by a smooth channel, and may be compared with the cotyloid portion of the ilium; the same piece of stone contains the shafts of two long bones, most probably femora. The length of the most perfect of these is 2 inches, and this does not include the distal end; the diameter of the

middle of the shaft is $2\frac{1}{2}$ lines; the surface of the preserved middle part shows the shaft to have been somewhat angular; the compact outer wall of the bone is about a quarter of a line thick; a large medullary cavity extends the whole length of the shaft, agreeing with the indications of terrestrial habits yielded by the bones before described; the extremities of the femora are spongy, but much decomposed and stained with iron-mould.

There are few genera of extinct reptiles of which it is more desirable to obtain the means of determining the precise modifications of the locomotive extremities than the *Rhynchosaurus*. The fortunate preservation of the skull has brought to light modifications of the Lacertine structure leading towards Chelonia and Birds, which before were unknown; the vertebræ likewise exhibit very interesting deviations from the Lacertian type. The entire reconstruction of the skeleton of the *Rhynchosaurus* may be ultimately accomplished, if the same interest in the collection and preservation of the fossils of the Grinsill quarries be continued, as has already produced so important an accession to Palæontology through the well-directed zeal of Dr. Ogier Ward and other members of the Literary and Scientific Association at Shrewsbury.

Thecodonts.

Among the inferior or squamate Saurians there are two leading modifications in the mode of attachment of the teeth, the base of which may be either anchylosed to the summit of an alveolar ridge, or to the bottom of an alveolar groove, and supported by its lateral wall. These modifications are indicated respectively by the terms "acrodont" and "pleurodont." A third mode of fixation is presented by some extinct Saurians, which, in other parts of their organization, adhere to the squamate or Lacertine division of the order, the teeth being implanted in sockets, either loosely or confluent with the bony walls of the cavity; these I have termed the "thecodont"* Lacertians: the most ancient of all Saurians belong to this group.

Thecodontosaurus, Riley and Stutchbury.—In the dolomitic conglomerate at Redland near Bristol, a formation considered to belong to the oldest or lowest division of the new red sandstone series, remains of reptiles have been discovered by Dr. Riley and Mr. Stutchbury†, which are allied in the form of their teeth to the typical Varanian Monitors, but differ in having the teeth imbedded in distinct sockets; to this condition, however, the *Varani*, among the squamate Saurians, make an approach in the shallow cavities containing the base of the teeth along the bottom of the alveolar groove.

In the ancient extinct genus in question the sockets are deeper, and the inner alveolar wall is nearly as high as the outer one; the teeth are arranged in a close-set series, slightly decreasing in size towards the posterior part of the jaw; each ramus of the lower jaw is supposed to have contained twenty-one teeth. These are conical, rather slender, compressed and acutely pointed, with an anterior and posterior finely-serrated edge, the serratures being directed towards the apex of the tooth, as in the genus *Rhopalodon* of G. Fischer; the outer surface is more convex than the inner one; the apex is slightly recurved; the base of the crown contracts a little to form the fang, which is subcylindrical. The pulp-cavity remains open in the base of the crown. In their microscopic structure, the teeth of the *Thecodontosaurus* closely correspond with that of the teeth of the *Varanus*, *Monitor*, and *Megalosaurus*. The body of the tooth consists of compact dentine, in which the calcigerous tubes diverge from an open pulp-cavity at nearly right angles to

* Odontography, part ii. p. 266.

† Geological Transactions, 1836, p. 349.

the surface of the tooth; they form a slight curve at their origin, with the concavity directed towards the base of the tooth; then proceed straight, and at the periphery bend upwards in the contrary direction. The diameter of the calcigerous tube is $\frac{1}{30,000}$th of an inch; the breadth of the interspace of the tubes is $\frac{1}{8000}$th of an inch. The crown of the tooth is invested with a simple coat of enamel.

This microscopic examination of the structure of the teeth, which I have been enabled to make by the kindness of Mr. Stutchbury, satisfactorily establishes the distinction between the Saurian of the Bristol conglomerate and the reptiles of the later member of the new red sandstone system in Warwickshire, which I have described under the name of *Labyrinthodon*.

Palæosaurus, Riley and Stutchbury.—In the formation which contained the jaw and teeth of the *Thecodontosaurus*, two other teeth were separately discovered, differing from the preceding and from each other; the crown of one of these teeth measuring 9 lines in length and 5 lines in breadth. It is compressed, pointed, with opposite trenchant and serrated margins; but its breadth as compared with its length is so much greater than in the *Thecodontosaurus*, that Dr. Riley and Mr. Stutchbury have founded upon it the genus *Palæosaurus*, and distinguish it by the specific name of *platyodon*, from the second tooth, which they refer to the same genus under the name of *Palæosaurus cylindrodon*. The portion of the tooth of the *Palæosaurus cylindrodon* which has been preserved, shows that the crown is sub-compressed and traversed by two opposite finely-serrated ridges, as in the *Thecodontosaurus* and *Rhopalodon*; its length is 5 lines, its breadth at the base 2 lines.

The vertebræ associated with these teeth are biconcave, with the middle of the body more constricted, and terminal articular cavities rather deeper than in *Teleosaurus*; but they are chiefly remarkable for the depth of the spinal canal at the middle of each vertebra, where it sinks into the substance of the centrum; thus the canal is wider, vertically, at the middle than at the two ends of the vertebra: an analogous structure, but less marked, obtains in the dorsal vertebræ of the *Rhynchosaurus* from the new red sandstone of Shropshire.

Besides deviating from existing lizards in the thecodont dentition and biconcave vertebræ, the ancient Saurians of the Magnesian conglomerate also differed in having some of their ribs articulated by a head and tubercle to two surfaces of the vertebra, as at the anterior part of the chest in Crocodiles and Dinosaurs. The shaft of the rib was traversed, as in the Ichthyosaur and Rhynchosaur, by a deep longitudinal groove. Some fragmentary bones indicate obscurely that the pectoral arch deviated from the Crocodilian and approached the Lacertian or Enaliosaurian type in the presence of a clavicle and in the breadth and complicated form of the coracoid. The humerus appears to have been little more than half the length of the femur, and to have been, like that of the *Rhynchosaurus*, unusually expanded at the two extremities. The femur is thus described by the discoverers of the present thecodont reptiles:—

"Two femurs, in a tolerable state of perfection, have fortunately been found; one, of the right side, exhibiting nearly the whole of the bone, the inferior condyles only wanting; the other is the left, and exhibits the condyles, but is very imperfect at the superior extremity. The first mentioned measures 10 inches in length; from the head to the middle of the trochanter 3 inches $\frac{6}{10}$ths; from the trochanter to the inferior condyle 5 inches $\frac{7}{10}$ths. In the left femur the transverse diameter of the condyles is 2 inches $\frac{5}{10}$ths; the centre of the cylinder 1 inch. They are curved in two directions upon

the axis, giving them somewhat a twisted form, or the shape of a long *f* antero-posteriorly. The trochanter is well preserved, wedge-shaped, and of considerable size, as may be seen by reference to the figures. The articular head is flattened at the space between the trochanter, and the articular extremity is more curved than any other part of the bone: the centre is nearly round, but a slight elevation or ridge exists on its posterior surface, in the situation of the linea aspera of the human femur. The condyles are flattened, the outer one being the larger; there is a deep depression between them posteriorly, and a very slight one anteriorly.

"On an attentive comparison of these femurs with those of the Crocodile and Megalosaurus, we again recognise a resemblance. A comparison with the femurs of the Monitors evidently shows that our animal cannot have belonged to that family. The femurs of the Monitor are much less curved, being nearly straight, and the trochanter is much nearer the articular extremity; characters sufficiently showing a wide difference between them."

The tibia, fibula, and metatarsal bones manifest, like the femur, the fitness of the thecodont Saurians for progression on land. The ungual phalanges are sub-compressed; curved downwards, pointed, and impressed on each side with the usual curved canal.

The general conclusions which may be drawn from the knowledge at present possessed of the osteology of the *Thecodontosaurus* and *Palæosaurus*, the antiquity of which the discoverers of these genera regard as being greater than that of any other vertebrated animals, excepting fishes, are, that in their thecodont type of dentition, biconcave vertebræ, double-jointed ribs, and proportionate size of the bones of the extremities, they are nearly allied to the *Teleosaurus*; but that they combine a Lacertian form of tooth, and structure of the pectoral and probably pelvic arch with these Crocodilian characters, having distinctive modifications, as the moniliform spinal canal, in which, however, the almost contemporary Rhynchosaur participates. It would be interesting to ascertain whether the caudal vertebræ are characterized, as in the Thuringian Protorosaur, by double diverging spinous processes*.

Cladyodon, nob.—In the new red sandstone (Keuper?) of Warwick and Leamington, there occur detached, pointed, trenchant, recurved teeth, the crowns of which are sometimes 1 inch 4 lines in length, and 5 lines across the base: they have been found in the same quarries as those containing the remains of the *Labyrinthodon*. In their compressed form, anterior and posterior serrated edges, sharp points, and microscopic structure, these teeth agree with those of the Saurian reptiles of the Bristol conglomerate. In their breadth, as compared with their length and thickness, they are intermediate between the *Thecodontosaurus* and the *Palæosaurus platyodon*; but they are larger, with longer and more recurved crowns, and thus more nearly approach the form characteristic of the teeth of the *Megalosaurus*†. From these teeth, however, they differ in their greater degree of compression, and in a slight contraction at the base of the crown; I therefore indicate the genus, of which, as yet, only the teeth are known, by the name of *Cladyodon*, and the species from the Warwickshire sandstones by the name of *Cladyodon Lloydii*, in testimony of the friendly aid of Dr. Lloyd of Leamington, to whose zealous co-operation I owe the materials for the description of the teeth of the present genus, and the still more remarkable ones of the British species of *Labyrinthodon*, with which the teeth of the *Cladyodon* are associated.

* This structure I have ascertained in the original specimen described by Spener, now preserved in the Hunterian Museum.

† One of the teeth of the *Cladyodon* is figured in the Memoir of Messrs. Murchison and Strickland on the Warwick Sandstones, Geol. Trans., second series, vol. v. pl. xxviii. fig. 6.

Order PTEROSAURIA.

The term *Ornithocephalus*, originally imposed by Soemmering on the genus *Pterodactylus*, Cuv., which is the type of the present extinct order of reptiles, would be much more applicable to the *Rhynchosaurus*; for although a more striking approach to the class of birds is made by the modification of the pectoral extremity which endowed the Pterodactyle with the power of flight, it is precisely in the structure of the cranium that it adheres most closely to the ordinary Saurian type of structure.

The genus *Pterodactylus* was ranked among the swimming-birds by Blumenbach, with the cheiropterous Mammalia (Bats) by Hermann and Soemmering, and has been proved to belong to the order of Reptiles by Cuvier. The *Pterodactylus longirostris*, from the lithographic slate of Pappenheim, was the earliest known species; the *Pter. brevirostris*, *Pter. medius*, and *Pter. grandis*, were next established, and subsequently the British species *Pter. macronyx* was determined by Dr. Buckland, from remains discovered in the lias of Lyme Regis, and which, before they came under the discriminative glance of the Oxford Professor, had passed as the bones of birds.

Of this species Dr. Buckland describes the principal bones of the extremities, and several vertebræ; the cranium has not yet been discovered. The valuable subject of the Professor's memoir is deposited in the British Museum; the Memoir is contained in the third volume of the second series of the Transactions of the Geological Society, and an accurate figure of the specimen is given, of the size of nature, at plate xxvii.*

A second stratum, in which the remains of Pterodactyles have been detected by Dr. Buckland, is the oolite slate of Stonesfield. Some fine specimens of the long bones of the extremities of Pterodactyles from that locality, in the collection of John Hunter, were referred by that celebrated anatomist to the class of birds.

Sauria Incertæ Sedis.

Polyptychodon.—A large species of Saurian is indicated by thick conical teeth, having the general character of those of the Crocodile, but distinguished by numerous, closely-set, longitudinal ridges, which are continued, of nearly equal length, to within 2 lines of the apex of the crown. These teeth have been described and figured in my 'Odontography' under the name of *Polyptychodon*. In their size and general form these Saurian teeth resemble those of the great sauroid fish, *Hypsodon*, Ag., but may be distinguished by the solidity of the crown, and the conformity of the structure of the dentine with that of the Crocodiles; also by the ridges on the exterior of the crown of the Hypsodon's teeth being alternately long and short, and terminating abruptly at different but commonly greater distances from the apex than in *Polyptychodon*, the interspaces between the longer ridges widening as they approach the apex. The tooth of the *Polyptychodon* is slightly and regularly curved, and invested with a moderately thick layer of enamel, of which substance the ridges are composed, the surface of the outermost layer of dentine being smooth. A tooth of this reptile from the lower greensand (Kentish-rag quarries) near Maidstone, in the collection of Mr. Benstead of that town†, has a crown 3 inches long, and 1 inch 4 lines across the base. The compact dentine is resolved by decomposition into a series of superimposed thin hollow cones, and the short and wide conical pulp-cavity is con-

* See also the interesting chapter on "Flying Saurians" in the 'Bridgewater Treatise,' vol. i. p. 221.

† Presented by that gentleman, since the reading of this Report, to the Museum of the Royal College of Surgeons.

fined to the base or fang. The cavity of the tooth in *Hypsodon* would appear to have been much larger, as it is in many predatory fishes, in which the teeth are more rapidly shed and renewed than in Crocodilian reptiles.

The teeth of *Polyptychodon* differ from those supposed to have belonged to *Poikilopleuron*, in the ridges of the crown being more numerous and close set, and in the transverse section being nearly circular instead of being elliptical: from the teeth of *Pliosaurus* those of *Polyptychodon* differ in being round and not three-sided, and in having longitudinal ridges over the whole surface of the crown; and from the teeth of *Mosasaurus* they differ in being ridged and not smooth.

Gigantic Fossil Saurian from the Lower Greensand at Hythe.

Under this head I have to notice some remains of a Saurian of marine habits, but most probably of the Crocodilian order, as gigantic as the *Cetiosaurus* or *Polyptychodon*, but, in the absence of dental and vertebral characters, not referable to any known genus. These remains were discovered by H. B. Mackeson, Esq. of Hythe, in the greensand quarries near that town, and include portions of the iliac, ischial and pubic bones, a large proportion of the shaft of a femur, parts of a tibia and fibula, and several metatarsal bones. In consequence of the absence of vertebræ and teeth, the present observations will be limited to indicating the characters by which these remains differ from previously known extinct genera of Saurians. In the first place, as the femur and other long bones have no medullary cavities, but a central structure composed of coarse cancelli, it is evident that the animal of which they formed part was of marine habits; but the best-preserved bone being a femur, this circumstance, independently of the size and shape of the metatarsals, at once negatives the idea that these remains belonged to the Cetacean order, whilst the form and proportions of the metatarsals equally forbid their reference to any other Mammalian genus.

Femur.—The portions of this bone secured by Mr. Mackeson include about the two distal thirds, excepting the articular extremity; its length is 2 feet 4 inches; its circumference in the middle, or smallest part of the shaft, is 15 inches 6 lines, and at the broken distal end, 2 feet 5 inches. These dimensions prove that the animal was equal to the most gigantic described *Iguanodon**. If the supposition of the proportion of the femur which has been preserved be right, this bone differs from that of the *Iguanodon*, not only in the want of a medullary cavity, but also in the absence of the compressed process which projects from the inner side of the middle of the shaft. The bone also expands more gradually than in the femur of the *Iguanodon*, and the posterior part of the condyles must have been wider apart in consequence of the posterior inter-condyloid longitudinal excavation being longer and wider.

Tibia and Fibula.—The portion of a tibia which has been preserved is compressed near its head, and the side next to the fibula is slightly concave. The longest transverse diameter is 8 inches 9 lines, and the two other transverse diameters at right angles to the preceding, give respectively 3 inches 3 lines, and 2 inches 6 lines. The bone soon assumes a thicker form, its circumference at about one-third from its proximal end being 16 inches 6 lines. The cancelli occupying the central portion of the bone are arranged in a succession of layers around a point nearest the narrower end of the transverse section. Lower down the tibia again becomes compressed, and towards the

* The length of the largest femur yet obtained of this Saurian is 4 feet 6 inches, its smallest circumference 1 foot 10 inches.

distal end the transverse section exhibits the form of a plate bent towards the fibula, and its narrowest transverse diameter is $2\frac{1}{2}$ inches.

The portion of the fibula is $11\frac{1}{2}$ inches long. In the middle it is flat on one side, slightly concave on another, and convex on the two remaining sides. It presents the same cancellous structure as the tibia, but the concentric arrangement of the layers of cells is more exact. Towards the opposite end of the bone the concave side becomes first flat, and is then produced into a convex wall, terminating one end of a transverse section of a compressed and bent thick plate of bone.

Metatarsals.—These bones exhibit the characteristic irregularity of length of the Crocodilian metatarsals. Of two imbedded in the rock, and apparently the innermost and second, of the left hind-foot, the former or smaller measured 1 foot in length and the latter 2 feet, having a diameter of 8 inches at its greater end, and of 4 inches 5 lines at its narrowest or middle part, and of 6 inches at its other extremity, which was imperfect. The whole of the bone within the compact outer crust consisted of cells varying from a half to two-thirds of a line in diameter. Portions of four other detached metatarsals are described.

Ilia, Ischia, Pubis, and Coracoid Bone.—These bones conform in the main to the Enaliosaurian type. The remains of the ilia are flat and nearly straight, and they gradually but slightly widen towards one end. Of one ilium a portion, 25 inches long and 10 inches across at the broadest end, is preserved, and of the other a fragment 20 inches in length.

The mesial extremities of the pubis and ischium are preserved in the same block of stone. The pubis differs from the Crocodilian type in its greater breadth. The portion exposed in this block is principally convex, but it becomes concave towards the opposite or median margin. At its broadest part it is 13 inches across, and its length is 17 inches. This expanded extremity is rounded, and the diameter of the corresponding expanded extremity of the ischium, which is obliquely truncated, is 9 inches. In another block of stone the expanded extremity of the opposite pubis is preserved, and measures 14 inches across and 22 inches in length.

The bone which bears most resemblance to a coracoid is 2 feet in length and 17 inches in its greatest breadth, and it varies in thickness from 3 to 5 inches. The breadth of this bone indicates the great development of the muscles destined for the movement of the fore-leg, whence it may be inferred that the anterior extremities were more powerfully and habitually used in progressive motion than in the Teleosaurian Crocodiles.

It will be sufficiently apparent, from the brief notice of the principal characters of these interesting remains here given, that they cannot have belonged to any of the genera of the great ambulatory terrestrial Dinosaurs; and, on the other hand, the length, thickness, and form of the condyles of the femur, and the size and shape of the metatarsal bones equally remove the Enaliosaurs from the pale of comparison.

There then remain, as claimants of the fossils in question, first, the great *Mosasaurus* of the Cretaceous formations, the locomotive extremities of which have not been yet discovered; secondly, the equally gigantic *Cetiosaurus brevis*, associated with the *Iguanodon* in the Wealden, and, from its organization, more likely than the *Iguanodon* to be found in later marine deposits; finally, the Reptile of the Maidstone greensand, to which the name of *Polyptychodon* has been provisionally assigned from the configuration of its teeth. But, since the teeth of the genus *Cetiosaurus* are not yet determined, the identity of this genus with *Polyptychodon* is open to suspicion; and subsequent discoveries may demonstrate that the great Saurian of the Hythe

greensand indicated by bones of the extremities, that of the Maidstone greensand by its teeth, and that of the Wealden formation recognized by its vertebræ, are all parts of the same extinct reptile.

Genus *Rysosteus*, nob.

I have been favoured by Mr. Johnson of Bristol, with the opportunity of examining a small anterior dorsal vertebra, (No. 177, of his interesting Collection,) half imbedded in its pyritic matrix, from the Bone-bed of Aust Passage, near Bristol.

Both articular ends of the body of this vertebra are concave, but deeper than in *Teleosaurus*, with a central short transverse linear impression. The lower part of the side of the body is raised into an obtuse longitudinal ridge, above which, between it and the transverse process, is a wide but not deep depression. The centrum slightly expands to the two extremities, which have a circular contour. The transverse process is broken off: its base, which is as deep as long, rests in a small proportion upon the centrum, but chiefly upon the side of the neurapophysis, the limits of which are not defined by a persistent suture. The neural arch rests upon the whole antero-posterior extent of the upper part of the centrum, rises nearly vertically to a height not quite equal to that of the centrum, then slopes abruptly inwards to support the base of the spine. This is nearly equal in antero-posterior extent to the centrum, and slightly increases in that direction by inclining over the interspace of the posterior oblique processes: it also slightly gains in thickness, and is terminated by a flat and rough surface, the contour of which is nearly parallel with that of the under surface of the centrum. The sides of the spine for two lines below the summit are wrinkled* or impressed by vertical or slightly oblique coarse grooves. The posterior oblique process is moderately long and slender; its flat elliptical articular surface looks downwards and slightly outwards. The non-articular surfaces of the vertebra are smooth, except near the summit of the spine, the lateral ridges and grooves of which form the chief characteristic of the present vertebra.

This vertebra, though it resembles those of a few species of Plesiosaur in the depth of its terminal articular surfaces, differs too much in its length and lateral compression to be referable to that genus; the rough and thick truncated summit of the spinous process rather indicates the species to have belonged to the loricate family of Saurians. It differs from the vertebræ of the Teleosaur and other known Amphicœlian Crocodiles in the form and vertical thickness of the transverse processes, in the lateral longitudinal ridge of the centrum, and in the antero-posterior extent and form of the spinous process. It differs from the vertebræ of the Labyrinthodon in the articular ends being at right angles to the axis of the centrum and not oblique; in the greater vertical thickness of the transverse process; and in the spine not being suddenly expanded and flattened at the summit, as in the dorsal vertebræ of the *Labyrinthodon*.

The following are dimensions of the vertebra of *Rysosteus*:—

	Lines.
Antero-posterior extent of centrum	11
Transverse diameter of articular end	5
Vertical diameter of articular end	6
Vertical diameter of entire vertebra	16
Antero-posterior extent of spinous process	10

* The name here proposed for the Saurian of the Bone-bed, from ῥυσὸς wrinkled, ὀστέον a bone, relates to this structure.

I have received other portions of *Rysosteus* from the Bone-bed at Westbury Cliff, on the Severn, eight miles from Gloucester.

Two spinous processes of fractured vertebræ are conspicuous and readily recognizable by their wrinkled surface and great antero-posterior extent; they agree also in size with the vertebra from Aust Passage, and seem to be evidently of the same species.

The distal end of a Saurian humerus and a nearly entire femur are associated with these vertebral fragments. The humerus has an angular and twisted shaft, and greatly expanded articular extremities, the surface of which is ridged like the spinous processes, but with somewhat wider intervals.

The femur equals the length of three vertebræ and a half; resembles that of the *Teleosaurus* in shape, but has the outer surface of the expanded extremities wrinkled, though in a minor degree than in the humerus. The correspondence of the long bones in size, and in the wrinkled character of part of their surface with the vertebræ, almost demonstrates that they belong to the same species of Saurian.

Order CHELONIA.

Family Testudinidæ, Tortoises, or Land-Tortoises.

New Red Sandstone Tortoises.—The most ancient of the evidences of Reptiles of the Chelonian order, in British formations, appear to be referable to Land-tortoises. The foot-prints upon the thin superimposed strata of the new red sandstone quarries at Corn-Cockle Muir, of which an account is given by Dr. Duncan in the Transactions of the Royal Society of Edinburgh for the year 1828, and those subsequently discovered in the same ancient formation at the quarries of Craigs, two miles east of the town of Dumfries, are regarded by Dr. Buckland as bearing most resemblance to the foot-prints of a small species of tortoise*.

Oolite Tortoises.—The impressions of horny scutes, about the size of those covering the carapace of a tortoise ten inches in length, occur not unfrequently in the oolitic slate of Stonesfield, and leave a light brown stain upon the matrix. These correspond so closely in form and in the arrangement and distinctness of the concentric lines with those of existing tortoises†, that the position which they originally held on the carapace may often be determined.

Family Emydidæ, Fresh-water Tortoises.

Emys, sp. indet.—In the museum of Prof. Bell there is a specimen of an *Emydian* Chelonite from the Eocene clay near Harwich, which differs from the *Emys testudiniformis* of Sheppey in its flatter figure.

The carapace is elliptical, gently convex at the middle and concave at the sides, the margins being slightly raised. The external surface of the osseous buckler is slightly rugous; the length of the carapace is 11 inches; its breadth at the suture between the fifth and sixth rib is 10 inches.

The first vertebral plate is nearly flat; the middle part of its posterior margin extends backwards about one line and a half. The second vertebral plate is of an oblong quadrangular figure, 6 lines in breadth: the third vertebral plate is six-sided and 8 lines in breadth, the two anterior sides being the shortest: the tenth and eleventh vertebral plates are broad.

* "On comparing some of these impressions with the tracks which I caused to be made on soft sand, clay, and upon unbaked pie-crust, by a living Emys and *Testudo Græca*, I found the correspondence with the latter sufficiently close, allowing for difference of species, to render it highly probable that the fossil footsteps were also impressed by the feet of land-tortoises." —*Bridgewater Treatise*, vol. i. p. 261.

† The *Emys centrata* is, however, so denominated on account of the resemblance of its scutes, in their concentric striation with those of tortoises.

The normal or rounded portion of the rib begins to project from the under surface of the expanded plate at two inches distance from the head of the rib; but the superincumbent expanded portions and their sutures are continued as far as the marginal plates; as in other full-grown *Emydes*.

Emys testudiniformis, nob.
Emys de Sheppey, Cuv.?

Most of the *Chelonites* from the Eocene clay of Sheppey belong to the marine family* of the order, from which the present species differs in the depth of the bony cuirass, the convexity of the carapace, the concavity of the plastron, and the extent of ossification of both these parts. The more immediate affinities of the present fossil are elucidated by the comparison of the points of structure which it displays with the anatomical characters of the carapace of the *Emys* and *Testudo*.

The specimen, on which the species *Emys testudiniformis* is founded, includes a large proportion of the first, second, third, fourth, fifth and sixth, with a fragment of the seventh expanded vertebral ribs of the left side; a small proportion of the second, third, fourth, fifth and sixth vertebral plates; the hyo- and hyposternals, and part of the entosternal bones of the plastron.

The first rib is 1 inch 10 lines, in greatest breadth; 1 inch 5 lines broad at its junction with the vertebral plates, and four-fifths of the vertebral margin is articulated with the second vertebral plate; one-fifth part, divided by an angle from the preceding, joins a corresponding side of the lateral angle of the third vertebral plate; in this structure it resembles both the genus *Testudo* and some species of *Emys*.

The third, fourth, fifth and sixth vertebral plates are of equal breadth as in *Emydes*; not alternately broad and narrow as in the *Testudines*: they are likewise of uniform figure, as in most *Emydes*; not variable, as in *Testudines*: the vertebral plates also resemble those of the existing *Emydes*, and particularly of the Box-terrapin (*Cistudo*) in form. The lateral margin of each is bounded by two lines, meeting at an open angle, the anterior line is only one-fourth part the length of the posterior one; and this resemblance may be stated with confidence, since the portion of the entosternal piece preserved in the plastron determines the anterior part of the fossil.

The ribs preserved in the present Chelonite differ from the corresponding ones of the Tortoises and resemble those of the *Emydes* in their regular breadth, and the uniform figure of the extremities articulated with the vertebral pieces; the anterior line of the angular extremity is nearly three times as long as the posterior one.

Further evidence of the relation of the present Chelonite to the freshwater family is given by the impressions of the epidermal scutes: those covering the vertebral plates (*scuta vertebralia*) agree with those of most *Emydians* in the very slight production of the angle at the middle of their lateral margins, which is bounded by a line running parallel with the axis of the carapace, except where it bends out to form that small angle.

The middle part of each side of the plastron, in the *Emys testudiniformis*, is joined to the carapace by a strong and uninterrupted bony wall, continued from a large proportion of the hyo- and hyposternal bones upwards to the marginal costal pieces. The median margin of the hyo- and hyposternals are articulated together by a linear suture, traversing the median line of the plastron, and only broken by a slight angle formed by the right hyposternal, which is a little larger than the left. A similar inequality is not unusual in both Tortoises and Emydes. The transverse suture is, of course, broken by the same

* See Proceedings of the Geological Society, Dec. 1, 1841.

inequality; that portion which runs between the left hyo- and hyposternals being two or three lines in advance of the one between the right hyo- and hyposternals. The posterior half of the broad entosternal piece is articulated to a semicircular emargination at the middle of the hyosternals; so that the whole plastron forms one continuous plate of bone. This is relatively thicker than in existing Emydes, resembling in its strength that of Tortoises; and it is likewise slightly concave in the middle, which structure is more common in Tortoises than in Emydians, save those in which the sternum is moveable; in most of the other species the sternum is flat or slightly convex.

I have shown in my paper on the Turtles of Sheppey*, that the carapace figured by Cuvier† was not sufficiently perfect to decide the affinities of the Chelonian to which it belonged; if the vertebral scutes were less broad and angular than in marine turtles, the vertebral plates—much less variable in their proportions—were, on the other hand, as narrow as in turtles. But with reference to the plastron of the Sheppey Chelonite, figured by Parkinson ‡, and supposed by Cuvier to belong to an *Emys* of the same species as the carapace above alluded to, I have been able to determine, by an examination of the original specimen in the museum of Prof. Bell, that it belonged to the marine genus *Chelone* and to the species *longiceps*. In the fossil *Emys* in Mr. Bowerbank's collection, the plastron being in great part preserved, establishes its nonconformity with the marine turtles, and manifests a striking difference from Parkinson's fossil plastron.

The entosternal piece is impressed, as in Tortoises and Emydes, by a median longitudinal furrow; a transverse linear impression traverses the hyosternals half an inch behind the suture of the entosternal; the second transverse line is not so near the first as in Tortoises, but bears the same relation to the transverse suture of the plastron as in most Emydes; it does not pass straight across the plastron, but the right half inclines obliquely inward to a more posterior part of the median suture than is touched by the left half. The third transverse line passes straight across the plastron between the posterior ends of the bony lateral walls, uniting the carapace and plastron.

	In.	Lines.
The breadth of the plastron is	5	10
The outer posterior extent of the lateral wall is	3	9
The breadth of the entosternum	1	5
The depth of the whole bony cuirass at the middle line is	4	0

In the convexity of the carapace and relative depth of the osseous box the Sheppey Chelonite slightly surpasses most existing species, resembling in this respect the *Emys ocellata* and *Cistudo Carolina*. The plastron is also slightly concave, as in the male of *Cistudo vulgaris*: it is, however, entire at the line where the transverse joint of the plastron exists in the Box-tortoises; and the extent and firm ossification of the lateral supporting walls of the carapace forbid likewise a reference of the fossil to those genera. The general characters of the present fossil, more especially the uniformity of size and breadth of the preserved vertebral plates and ribs, prove it to be essentially related to the freshwater or Emydian Tortoises. It exceeded in size, however, almost all known Emydians, and was almost double the dimensions of the Emydian species (*Cistudo Europea*) now inhabiting central Europe. It appears, like the *Cistudines*, to have approached the form of the land-tortoises, in the convexity of the carapace, but without possessing that division and hinge of the plastron which peculiarly distinguishes the box-tortoises. In the thickness and strength

* Geological Proceedings, December 1, 1841.

† Ossem. Foss., tom. v. part iv. pl. xv. fig. 12.

‡ Organic Remains, vol. iii. pl. xviii. fig. 2.

of the bones of the buckler, especially of the sternum, we may discern an affinity to *Testudo*.

Assuming that the Chelonite here described may be identical with that of which the carapace from Mr. Crow's collection is figured in the 'Ossemens Fossiles*,' the '*Emys de Sheppey*' of Cuvier will be one of the 'Synonyms' of the present species. Mr. Gray, in his 'Synopsis Reptilium,' has given Latin names to all the fossil reptiles indicated or established by Cuvier, and has called the 'Emys de Sheppey' '*Emys Parkinsonii*,' referring as representations of this species, not to the figure of the carapace above cited, which may belong to the same species as the present *Emys*, but to the figure of the plastron, copied by Cuvier from 'Parkinson's Organic Remains,' and to the figure of the skull in the same work, both of which most unquestionably belong to the genus *Chelone* and not to the genus *Emys*.

The '*Emys Parkinsonii*' of Mr. Gray is a synonym of my *Chelone longiceps*. Cuvier's name,—which, besides the claim of priority, is the honest result of labour devoted to the elucidation of its subject,—if rendered into Latin would be *Emys toliapicus*; but as the species to which it refers may not be the one here described, and is not the only freshwater tortoise which the clay of Sheppey has yielded; and since the characters of the present species have not, hitherto, been defined nor its affinities to the land-tortoises been pointed out, the interests of science, it appears to me, will be best consulted by naming the present species *Emys testudiniformis*.

The fossil here described is from the Eocene clay of Sheppey Island, and forms part of the collection of J. S. Bowerbank, Esq.

Platemys Bowerbankii, nob.—Another specimen from the same rich collection of Sheppey remains actually indicates a distinct species of the freshwater family of *Chelonia*, which from its more depressed figure, its size, and the general form of the sternum, most probably belonged to the *Platemydian* division of that family †.

The sternum is 13 inches in length and 10 inches in breadth; it is broader before than behind, rounded in front, notched behind: the surface is nearly flat, slightly convex at the anterior part, and as slightly concave behind.

The lateral bony wall or ala uniting the plastron to the carapace is 5 inches in length or antero-posterior extent, and it commences 3 inches behind the anterior extremity of the plastron. The episternals meet in advance of the entosternal, the length of the suture joining their anterior extremities, being 7 lines: from the peripheral end of this suture to that of the suture between the episternal and hyosternal bones is 2 inches 6 lines: from the latter suture to the anterior concavity of the lateral wall is 5 lines. In a tortoise with a plastron 13 inches long, the length of the same suture was $1\frac{1}{2}$ inch, and the suture between the episternal and hyosternal bones is nearer the lateral wall. The *Emydes*, especially *Emys* (*Platemys*) *depressa*, most resembles the fossil, especially in the more important character of the relative length of the lateral wall and suture.

The carapace presents the same conformation and regularity of size of the vertebral plates and ribs as in the *Emys testudiniformis*; but it is flat, even slightly concave along the middle tract; and has somewhat narrower vertebral plates, of which the third to the eighth may be distinguished in the fossil; the ninth being concealed by the union of the vertebral extremities of the 7th pair of expanded ribs.

* Ed. 1824, vol. v. part ii. pl. xv. fig. 12.

† *Hydraspis*, Bell and Gray.

The vertebral plates are all smooth and flat; their dimensions are as follows:—

	In.	Lines.
Length of the fourth plate	1	11
Greatest breadth	1	3
Length of the fifth plate	1	8
Greatest breadth	1	3
Length of the sixth plate	1	6
Greatest breadth	1	3
Length of the seventh plate	1	1
Greatest breadth	1	3
Length of the eighth plate	0	9
Greatest breadth	1	0

In the circumstance of the vertebral plates in this fossil decreasing in length without losing breadth, as well as in the junction of the seventh pair of ribs, the present fossil resembles the Sheppey carapace from Mr. Crow's collection figured by Cuvier; which may, therefore, have belonged to the present species of *Platemys*.

Platemys Bullockii, nob.—A very fine plastron of a *Platemys* from Sheppey was obtained by the British Museum at the sale of Bullock's collection, which differs from the preceding in the finely punctate character of the external surface of the bone, and in the narrower notches between the body of the plastron and the lateral alæ or uniting wall. The following are dimensions of this specimen:—

	In.	Lines.
Length	16	6
Extreme breadth (anterior to lateral wall)	8	0
Breadth or transverse extent of lateral wall	2	6
Antero-posterior extent of lateral wall	5	6
Antero-posterior extent of carapace anterior to lateral wall	5	0
Antero-posterior extent of carapace posterior to lateral wall	6	0

The anterior contour of the sternum is rounded; the posterior termination is notched. The lateral wall extends horizontally, almost parallel with the plane of the sternum, and expands to join, by a wavy suture, the marginal plates; six of these are preserved on each side; their lower margins form a very open angle. The anterior part of the entosternum is bounded by two nearly straight lines, converging forwards at an angle of 65°, with the apex rounded off; the posterior contour of this bone is semicircular. The length of the entosternal is 2 inches 10 lines; its breadth 3 inches 7 lines.

The chief peculiarity of this plastron is the intercalation of a supernumerary piece of bone between the hyosternal and hyposternal elements, on each side; so that the plastron is crossed by two transverse sutures, instead of one; each suture being similarly interrupted in the middle by an angular deflection from the right, half an inch back, to the left side. The extremities of the transverse sutures terminate each at the apex formed by the inner or lower border of the parallel marginal plates. The first or anterior of these sutures is distant from the anterior margin of the plastron 6 inches 5 lines: the second suture is distant from the same margin 8 inches 9 lines: the right half of the suture, which is a few lines in advance of the left, is the part from which these measurements are taken.

It might be suspected that the transverse impressions of the second or third pairs of sternal scutes had here been mistaken for a suture; but due care was observed to avoid this error: the sternal scutes have left obvious impressions, which prove that they were in the same number as in the Platemydians generally, and quite distinct from the sutures in question.

Thus the first median scute is in the form of an ancient shield; its posterior apex impressing and crossing the anterior apex of the entosternum. The posterior transverse boundary of the succeeding pair of sternal scutes crosses the plastron $4\frac{1}{2}$ inches from its anterior margin; that of the third pair of scutes crosses at $7\frac{1}{2}$ inches from the anterior border, and between the two transverse sutures; that of the fourth pair at 10 inches distance from the anterior margin, and about $1\frac{1}{4}$ inch behind the second transverse suture; passing straight across the plastron between the posterior concave margins of the lateral walls. The posterior boundary of the fifth pair of scutes inclines obliquely backwards from the median line, as usual; it is 3 inches behind the preceding transverse impression.

It is in the interspace of these impressions that traces of the transverse suture between the hyposternals and xiphisternals are obvious, about 4 inches from the posterior extremity of the plastron. If these traces were not so obvious, it might be supposed that the xiphisternals were of unusual length, entering into the formation of the lateral wall, and extending backwards from the second transverse suture to the end of the plastron; but this disproportion would be hardly less anomalous than the existence of the additional pair of bones intercalated between the hyo- and hyposternals which this present fossil evidently displays.

In most of the existing large *Emydes* and *Platemydes*, the median transverse suture traverses the plastron a little behind the third pair of scutes, or across the fourth pair; so that the second transverse suture in the fossil has the analogous position, and accordingly has most right to be regarded as the normal boundary between the hyo- and hyposternals. One of the most distinctive characters of the present extinct *Platemys* is, therefore, the division of each hyosternal bone into two, the sternum consisting of eleven instead of nine pieces; if the very interesting anomaly which it displays be not an accidental or individual variety.

The chief difference in regard to the sternal scutes, is the addition of two small ones anteriorly, one on each side of the median anterior pair in the fossil.

The obtuse ridge which forms the angle between the carapace and plastron is preserved in the fossil.

Tretosternon punctatum, nob.—In the rich collection of fossil remains belonging to Sir P. Egerton, there is the posterior part of the carapace of a fine species of freshwater tortoise, which, by its broad and extremely flattened form and sculptured surface, is evidently closely allied to the genus *Trionyx*, but which, from the impressions of distinct horny scutes, is essentially related to the Emydian family, and is nearly allied to the genus *Platemys*, D. & B. (*Hydraspis*, Bell.): this portion of carapace contains the fifth to the twelfth vertebral plates inclusive, and the five posterior pairs of expanded vertebral ribs. The external surface of both elements of the carapace is closely pitted with minute irregular impressions, smaller than a pin's head, and along their sutural margins for the extent of two or three lines by straight and parallel linear impressions, at right angles or nearly so to those margins: the pin-head impressions are sparing or absent at these striated margins.

The breadth of the carapace, across the fourth pair of ribs, is $13\frac{1}{2}$ inches: the length of the moiety of the carapace here preserved is 9 inches: the entire length would be, probably, 17 inches. The flattened ribs gradually expand towards their distal extremity.

The close resemblance which this species makes to the *Trionyces*, in the sculpturing of the external surface of the carapace, is very striking; but the impressions of the horny scutes, and the non-continuation of a narrow tooth-

like portion of the rib from the distal end of the expanded part, are essential distinctions.

The entire and rounded terminal margins of the truncated and expanded extremities of the ribs, beyond which there is not the slightest trace of projecting tooth-like processes, strongly indicates that the marginal plates were either wanting or rudimental, as in the genus *Cryptopus*.

This fossil is from the Purbeck limestone.

In the collection of Mr. Bowerbank is preserved the left half of the plastron of the same species of freshwater tortoise, from the Purbeck limestone, at Swanage, equal in size and probably of the same species as the preceding, but with fainter impressions on the external surface. This Chelonite includes the hyosternal, the hyposternal, and a considerable part of the xiphisternal bones, but wants the extremity of this bone. It is a very remarkable and characteristic fossil, chiefly on account of the great extent of the lateral wall, which is continued outwards, in the same plane with the rest of the plastron, as in the Emydian subgenus *Platysternon*, Gray, accompanied by an unusual width of the notches, anterior and posterior to this wall, for the emergence of the fore and hind-feet. The length of this fossil, taken along the median suture, is 13 inches; the breadth of the sternum along the median transverse suture must have exceeded 12 inches. The antero-posterior extent of the contracted part of the lateral wall is 7 inches; that of its expanded outermost part 9 inches; the antero-posterior diameter of the hyposternal bone 4 inches 4 lines; extent of transverse suture between this and the xiphisternal 3 inches. The outer and anterior angle of the xiphisternal has a shallow angular notch which receives a corresponding process of the hyposternal: the median margin of the hyposternal has a semicircular piece cut out of it just where it joins the hyosternal: the bone gradually narrows off to the edge of this emargination, which is exposed, by a careful removal of the matrix, without any trace of fracture of the bone. If it be, as it seems, a natural structure, then the centre of the sternum must have presented an elliptical vacuity, closed by membrane or cartilage of nearly two inches diameter, situated immediately behind the transverse suture uniting the hyo- and hyposternals. Such an approximation to the *Trionyces* and *Chelones* presented by an extinct species, which from the extensive lateral union by a continuous bony plate of the side of the plastron with the carapace, and from the complete ossification of the latter is essentially an Emydian species, forms a very interesting transitional modification, especially if it be combined, as there seems good reason to believe, with the sculptured surface of a remarkably flattened carapace, such as the Chelonite, in Sir P. Egerton's collection, from the same stratum and locality presents.

The sternum, like the carapace above mentioned, is impressed by the margins of distinct scutes.

The transverse line bounding the second sternal scute has the same relative position as in the *Testudo Schweigeri* and *Platemys planiceps*. The two succeeding sternal scutes have a more equal antero-posterior extent than in those species. The impression commences at the median line, nearly an inch in advance of the transverse suture and three inches behind the second transverse scute, and describes a slight curve which is convex towards the anterior part of the plastron. The third scutal line commences from the middle of the median emargination, and instead of running parallel with the preceding line, as in the Tortoises and ordinary Emydes which I have examined, it inclines backwards as it passes outwards, and terminates at the middle of the posterior lateral emargination. The fifth scutal line is oblique, as in the Emydians generally, and here therefore runs parallel with the fourth line at a distance

of three inches and a half from it. The line bounding the lower part of the marginal scutes, which in Tortoises is either parallel with or a little above the suture uniting the lateral wall of the plastron with the marginal plates, here intersects the marginal wall of the plastron at a distance of from two-thirds of an inch to one inch and a half from that margin: impressions of four of the marginal scutes may thus be traced upon this part of the sternum, a structure in which the present fossil differs most remarkably from all known existing Tortoises. This difference it is the more necessary to bear in mind, since, in the antero-posterior extent as well as the transverse extent of the lateral wall of the sternum, and in the form and extent of the emarginations which bound the anterior and posterior part of this wall, the present fossil exhibits a closer resemblance with the Land-tortoises than with the ordinary *Emydes*. But the external surface of the plastron, instead of being slightly concave, as in most tortoises, is slightly convex; and where the plastron is convex externally in existing tortoises, namely, at the outer margin of the lateral wall, the fossil exhibits a slight concavity. In short, the character of the surface is such as would lead one having in his mind the plastron of a Tortoise as the ground of comparison, to suppose, at the first sight of the fossil, that he was looking on the inner side of the plastron; but the distinct and well-marked impressions of the epidermal scutes proves that it is actually the outer surface of the plastron which is here exposed. The anterior margin of the plastron is truncated, as in most Platemydians.

The osseous basis of the present plastron is half an inch in thickness; the structure of the bone is compact at the surface, including a coarsely spongy diploë, as in the Chelonians generally.

Portions of ribs of the *Tretosternon punctatum**, which from their specific punctation and sculpturing of the outer surface have been referred to the genus *Trionyx*, have been discovered by Dr. Mantell in the Wealden of Tilgate.

Amongst recent Emydians an approach to the *Trionyces* is made by the subgenus *Cryptopus* (*Emyda* of Gray), inasmuch as the marginal plates, especially of the posterior free margin of the carapace, exist in a rudimental or abortive state, as small granulated ossicles, suspended in the integument covering that border.

The subgenus *Chelydra* manifests its affinity to *Trionyx* by another modification of its osseous structure, viz. the absence of the lateral osseous walls, or alæ joining the plastron to the carapace, which are united only by flexible cartilage, throughout life.

No known existing species of Emydian has a free unossified central space in the sternum in the full-grown state; but this is an immature character common to all Chelonians, and is persistent in marine Turtles and *Trionyces*.

In the present highly interesting extinct genus, *Tretosternon*, it would appear that the absence of marginal plates, and a cartilaginous union of the plastron with the carapace, were associated likewise with a small vacuity in the middle of the sternum of the mature animal. The evidently feebly-developed scutes, and the sculpturing of the external surface of the flattened carapace, complete the last step in the transition from the Elodite to the Potamite families of Chelonians in the system of MM. Dumeril and Bibron.

Platemys Mantelli, Emys de Sussex, Cuv., *Emys Mantelli*, Gray.—The fossils discovered by Dr. Mantell in the Wealden strata of Tilgate Forest, and the resemblance of which to the flat species of Emydian discovered by M. Hugi in the Jura limestone at Soleure has been pointed out by Cuvier, are referable to the Pleuroderal section of the Emydian family, as arranged by

* Illustrations of the Geology of Sussex, 4to, pl. vi. figs. 1, 3 & 5.

Messrs. Dumeril and Bibron*, and, in that section, to the genus *Platemys*: not enough of the skeleton of any individual has yet been obtained to afford a foundation for a specific character.

Large Emydian from the Kimmeridge Clay.—In the museum of Sir P. Grey Egerton is preserved the pubic bone of a large Emydian tortoise, obtained from Heddington Pits. The bone measures $4\frac{1}{2}$ inches in length, and 2 inches 10 lines in the breadth of the symphysial plate. As its specific deviations, particularly in regard to the length of the sternal process, from the pubis of ordinary Emydians are well marked, it may probably belong to a species of *Platemys*.

Footsteps of Emydians in New Red Sandstone.—Among the numerous footsteps of Reptiles impressed upon the sandstone of Stourton Quarries, Cheshire, those of an Emydian Tortoise of moderate size are not uncommon.

Genus *Trionyx*.

Certain British fossils from the secondary formations, referred to *Trionyx*, have been proved to belong either to another family of Chelonians, or to a distinct class of animals. We learn from Dr. Buckland, that the supposed *Trionyx* from the new red sandstone at Caithness (Caithness slate), has been pronounced by M. Agassiz to be part of a fish: it is referable to the ganoid genus *Coccosteus*.

I have as yet seen no Chelonite from the Wealden freshwater formations that can be confidently affirmed to belong to *Trionyx*. The specimen described and figured in the 'Illustrations of the Geology of Sussex,' 4to, p. 60, pl. vi. fig. 8, is the dermal scute of the Crocodilian genus *Goniopholis*, as Dr. Mantell himself has subsequently recognized: the other portions (pl. vi. figs. 1, 3, 5) belong, as already observed, to the *Tretosternon punctatum*, a species which, like the *Goniopholis*, is common to the Wealden of Tilgate and the Purbeck limestone.

Femur from lias at Linksfield.—I have been favoured by Mr. Robertson of Elgin, with the examination of a Chelonian femur, $4\frac{1}{2}$ inches in length, from a stratum at Linksfield, in which remains of *Plesiosaurus* and *Hybodus* occur; and this femur, though not identical in form with that of any *Trionyx* with which I could compare it, yet resembles the modifications of the bone in that genus more closely than in Tortoises, Emydians or Turtles.

Although some of the turtles of the Eocene period, as the *Chelone longiceps*, present such modifications of the jaws as seem to have adapted them to habits and food analogous to those of the *Trionyx*, yet evidences of this genus, to which the destruction of the eggs and young of Crocodiles is more particularly assigned in the Nile and Ganges, are not wanting in certain localities where the London clay appears to have been deposited under circumstances analogous to those at the termination of equally gigantic rivers.

Unequivocal portions of a true *Trionyx* have been obtained from the Eocene clay at Sheppey, and at Bracklesham: they are also associated, as in the Paris basin, with remains of *Anoplotherium* and *Palæotherium* in the Eocene lacustrine deposits of the quarries at Benstead in the Isle of Wight.

Family Chelonidæ, Thalassian† family, or Turtles.

Genus *Chelone*.

Chelone planiceps, nob.—The oldest British geological formation from which

* Erpétologie, 8vo, 1835, tom. ii. pp. 172, 372.

† "Cheloniens Thalassites," Dumeril and Bibron, *l. c.*, p. 506. The unfortunate similarity of the generic name of the marine Chelonians, viz. *Chelone*, with the name of the order, *Chelonia*, renders the term 'thalassian' convenient, in allusion to the peculiarities of the marine species or 'Turtles.'

fossil remains, clearly referable to the marine genus *Chelone*, have hitherto been found, is the Portland sandstone.

Prof. Buckland possesses portions of the carapace and a beautiful specimen of the skull of a Chelonian from the Portland sandstone, which, in the large size of the orbits, the breadth but otherwise small size of the external nostril, the extent of the osseous plate covering the temporal fossæ, and formed principally by the expanded posterior frontal and parietal bones, presents unequivocal characters of a marine species. It differs, however, from all other known recent and most extinct Turtles, in having the cranium more depressed, the nasal bones divided by a distinct transverse suture from the pre-frontals, and by some other minor differences, in which an affinity to the Platemydian family may be traced. The length of this cranium is 4 inches 4 lines, its greatest breadth 4 inches. The chief modification of external form is the deep emargination of the lower border of the cranium, between the malar and tympanic bones; a character by which the present species approaches *Emys* and *Testudo*. The *Chelone longiceps* of the Eocene tertiary formations makes a similar but less marked approach to *Emys*; and the present Turtle also resembles *Chel. longiceps** in the form of the mastoid bone, which, instead of forming a thick convexity behind the wide tympanic cavity, forms a smooth and slightly concave, moderately broad, semicircular plate of bone. The muzzle is, however, as short in the Turtle of the Portland stone as in ordinary species of *Chelone*; the distance, for example, from the anterior part of the orbit to the end of the muzzle, is only 11 lines. The median frontal sends a narrow pointed process forwards between the pre-frontals, as far as the suture which divides them from the nasal bones. The breadth of the interorbital space is relatively less than in recent Turtles, or than in the *Chelone longiceps*: it measures 8 lines.

The median frontal enters into the formation of the upper part of the orbit, in a greater proportion than in *Chel. mydas*: in the *Chel. imbricata* it is excluded by the union of the post-frontal and pre-frontal bones. The outer surface of the skull is rather undulated, marked with fine striæ and punctures, but not rugous, as in *Chel. breviceps*†; the nasal bones are convex, and impressed with larger pits. The upper boundary of the nasal aperture is straight, the lateral ones curve to a point below: the breadth of this aperture is 7 lines; that of the orbit is 13 lines.

The nasal process of the superior maxillary is characterised by a slightly raised rough portion.

The lower jaw closely conforms to the ordinary Thalassian type; the symphysis is convex, oblique, and as short as usual; there is no approximation to the peculiar condition of this part in the Harwich Turtle (*Chel. planimentum*‡).

The suture between the supra-angular and dentary piece does not make so long and sharp an angle forwards, as in the *Chelones mydas* and *Caretta*; the coronoid process is rather higher, and the dentary piece sends out a ridge which seems to have bounded the insertion of the temporal muscle below.

Thus the present cranium offers ample proof of its specific distinction from that of any previously described *Chelone*; and, while it has all the essential characters of that marine genus, exhibits some points of resemblance to the Emydians, as in the minor breadth of the interorbital space, the deep concavity of the lower border of the skull behind the orbit, and in the form of the mastoid bone. The separate nasal bone, which is the most interesting

* See Proceedings of the Geological Society, December 1st, 1841.
† Ibid. ‡ Ibid.

structure in the present skull, though hitherto unknown in the genus *Chelone*, has been met with in the Platemydian subgenus, *Chelodina*, the cranium of which, in other respects, closely conforms to the ordinary Emydian type, and has not the temporal fossæ protected by bone, as in the *Emys* (*Podocnemis*) *expansa**.

Chelone obovata, nob.—The most complete and beautiful specimen of a fossil turtle, from secondary strata, that I have yet seen is one from the estuary limestone formation of the Isle of Purbeck, in the Collection of Channing Pearce, Esq. of Bradford, Wiltshire.

This species differs from the *Chelone Benstedi* of the chalk, from the Glaris Turtle, and from all the well-determined Eocene species in the form of the carapace, which, although obtusely pointed behind, begins to contract to that extremity only at its posterior third part; it gradually widens through the two anterior thirds of its extent, and is broadest at the junction of the fifth and sixth ribs; the contour being obversely ovate, or with the broader end turned downwards. This modification of form arises, not from the superior length of the fifth and sixth pairs of ribs, but from the breadth of their sternal appendages, called marginal plates. The internal surface of the carapace is exposed to view, and is shallower than in any other *Chelone*; resembling in this character the *Trionyx* and *Tretosternon*; the margins of the carapace are slightly bent upwards, as in some *Emydes*.

The first vertebral plate is shorter antero-posteriorly, and less deeply emarginate anteriorly than in the Maestricht *Chelone*†, and the first pair of expanded ribs is narrower. This well-marked difference fortunately occurs in the only parts in which a comparison could be established with the Turtles from a stratum so nearly contemporaneous with the Purbeck beds. The first rib is straight, and rather narrower in proportion than in the Eocene Turtles; in *Chelone mydas* this rib is the broadest of the series. It very gradually contracts into its dentiform extremity, which on the left side appears to have been separated by a narrow membranous space from the anterior marginal plates, but not on the right side. The second rib is broader in proportion to the first than in any other species of *Chelone*, recent or extinct; more so even than in the *Trionyx*, in which the first rib is narrower than the second. The third and fourth ribs are the broadest.

	In.	Lin.
The length of the expanded part of the fourth rib is .	3	0
The breadth of the expanded part of the fourth rib .	1	5
The length of the dentiform extremity	1	0

The rest gradually diminish in length and breadth. They are all as flat upon the under surface as in *Chelone mydas*, presenting a great contrast to the Harwich species, *Chel. planimentum*, in this respect.

The median row of vertebral plates, after the first, are as narrow as in most *Chelones*, and appear, as far as their form can be traced from an inside view, to resemble those of the *Chel. mydas* and *Chel. longiceps*, but to have been narrower than in the extinct Eocene Turtles: the length of the fourth vertebral plate in the *Chel. obovata*, for example, is 1 inch 3 lines, its greatest breadth is 6 lines. The eleventh six-sided plate, which resembles a triangle, with truncated angles, and is wedged between the last pair of ribs, is here divided by a transverse suture into two nearly equal parts. The twelfth plate

* The different proportions in which the cranial bones, especially the post-frontals, enter into the formation of the bony covering of the temporal fossæ in the *Emys expansa*, serve to distinguish the skull of a *Chelone* from that of this exceptional example of an Emydian with the temporal fossæ covered by bone.

† Cuv. Ossem. Foss., tom. v. pt. 2. pl. xiv. Tortues, fig. 1 and 2.

is nearly twice as broad as long, and has convex lateral margins: the thirteenth vertebral plate, or the last of the marginal plates, is relatively broader than in existing turtles, and has its posterior margin more feebly emarginate. The marginal plates differ in the superior expanse of those attached to the fifth, sixth and seventh ribs. That to which the eighth rib is attached corresponds with the tenth in the *Chel. mydas*, and the eleventh projects in an angular form the interspace between the dentiform extremity of the eighth rib and the twelfth vertebral plate. The thirteenth marginal plate sends a similar process between the seventh and eighth ribs: the exterior margins of all the marginal plates are straight, and the carapace is bounded by an unbroken contour. The diameter of the marginal plate attached to the fifth rib, parallel with the axis of the carapace, is 1 inch 6 lines; the diameter transverse to the carapace is 6 lines:

	In.	Lin.
The length of the carapace	10	9
The breadth of the carapace	9	6

A considerable proportion of the plastron of the same individual is preserved, together with part of the bones of the hinder extremities, and both afford essential characters of the genus *Chelone*. The plastron of the *Chelone obovata* resembles that of the Eocene Turtles in the greater extent of ossification, and especially in the greater breadth of the xiphisternals, as compared with the recent species; but it differs from all other known species of *Chelone* in the greater depth of the notches at the anterior part of the hyosternals and at the posterior part of the hyposternals, which notches correspond with those that in the more fully ossified plastrons of *Emydes* give passage to the four locomotive extremities. The essential condition, however, of the plastron of the marine turtles is preserved, first, in the defective ossification of the lateral margins of the plastron between the hyo- and hyposternals, which are not co-extended and united to form a lateral wall of support to the carapace, as in the *Emydes*; and, secondly, in the form, and union by gomphosis, of the xiphisternals with the hyposternals: what proportion of the central part of the plastron continued unossified, the condition of the specimen does not allow of determining. There is evidence of the concavity of the sternum along the middle of the under surface, as in most *Chelones*.

The hyosternal is chiefly remarkable for the sudden expansion of the external radiated process, which occasions a notch at its posterior part, at the lateral unossified interspace between the hyo- and hyposternal bones, almost as deep as that which is anterior to the radiated process. The hyposternal bone presents likewise a similar modification of form. By this peculiarity of form the present species might be known by a single detached hyosternal or hyposternal bone. The tooth-like process of the hyosternal, which is implanted in the xiphisternal, is received into a notch, the inner boundary of which is much deeper than the outer.

The breadth of both the xiphisternals, taken across the termination of this notch, is 3 inches: they are separated by an angular fissure for the extent of an inch at their posterior interspace, but their median dentated margins meet in the rest of their extent, which is about one inch and a half.

The breadth of sternum, across the hyposternal bones, is 8 inches; the least antero-posterior extent of the conjoined hyo- and hyposternals is $4\frac{1}{2}$ inches.

In this admeasurement, as compared with the transverse extent of the same bones, the *Chelone obovata* differs in a marked degree from the *Chel. longiceps* of Sheppey, and indeed approaches nearer to the existing species of *Chelone* than do the Eocene Turtles. The adherence to the thalassian type is likewise well exhibited in the present fossil by the forms and proportions of the

principal bones of the hind-extremities or paddles, which are much shorter as compared with the fore-paddles and the body generally, in the marine than in any of the freshwater or land *Chelonia*. The length of the femur is 1 inch 9 lines; that of the tibia 1 inch 7 lines. The articular extremities are too imperfect to allow of a comparison of the forms of these bones with the corresponding ones of existing species.

Since the carapace of the *Chelone obovata* approaches, in those modifications by which it differs from other turtles, to the Emydian type, it is not improbable that the skull of the Chelonian, above described, from the contiguous subjacent stratum of Portland stone, which offers analogous approximations to the Emydian group, may belong to the same species.

Wealden Chelone, sp. indeterm.—Portions of the carapace and plastron, and bones of the extremities of a large species of marine turtle, some of them indicating individuals with a carapace nearly three feet in length, have been discovered by Dr. Mantell in the Wealden strata of Tilgate Forest, and are figured in his valuable 'Illustrations of the Geology of Sussex.'

No specific characters are deduced from these fossils, and the nature of the specimens seems not to have allowed the approximation to be carried closer than to the marine genus *Chelone*. With regard to one of the specimens, (pl. vi. fig. 2.) however, Mr. Clift's authority is quoted for its resemblance with the corresponding part of *Chelone imbricata*, and Dr. Mantell acknowledges that "as Cuvier had referred the turtles of Melsbroeck to the *Emydes*, we at first entertained doubts whether our appropriation of this specimen to the *Cheloniæ* were correct. Mr. Clift's remark, however, tends to confirm the opinion that it belongs to a marine turtle," *loc. cit.*, p. 62.

After a careful comparison of the specimens in the Mantellian Collection* in the British Museum, I have come to the conclusion that the Wealden species differs from *Chelone imbricata*, *Ch. carinata*, and other known species in as great a degree as do many of the other extinct *Chelones*, in regard to the greater extent of the ossification of the costal interspaces and of the sternum.

In the convexity of the under side of the vertebral ribs; and in the modifications of the form of the episternal, hyosternal and hyposternal bones the Wealden species offers the nearest resemblance to the *Chelone planimentum* of the Harwich Eocene clay. It is to be regretted that this relationship cannot be more decisively tested by a comparison of the skulls, and especially of the lower jaw of the two species: but these parts of the skeleton appear not to have been as yet discovered in the Wealden.

Chelone pulchriceps, nob.—The cranial anatomy of a fossil turtle from the superincumbent beds of lower greensand differs from that of other known species, but presents the nearest resemblance to that of the turtle from the Portland stone.

A small cranium of the present species of *Chelone*, from the greensand near Barnwell, Cambridge, in the museum of the Rev. Thomas Image of Whepstead, in the same county, is depressed, and likewise has the nasal bones marked off by a suture from the anterior frontals, but in a different manner from that in the skull of the Portland turtle. The characters of the genus *Chelone* are clearly expressed by the extensive roof of bone overarching the temporal fossæ, and by as large a proportion of this roof being formed by the post-frontals as in existing *Chelones*. The orbits are also large, and their superior interspace is broad.

The median frontals form a small proportion of the upper border of the or-

* No. 2338, "Sternal plate of a marine turtle," *MS. Catalogue of Mantellian Museum*, now in the British Museum, is unquestionably the left hyposternal, and part of the lateral wall, supporting the carapace of a Tortoise or Emys.

bits; the anterior extremities of the median frontals, instead of converging to a point, are extended forwards, between the anterior frontals, in a broader proportion than in the Portland Turtle, and are obliquely truncated: it is only in the genus *Chelys* among existing Chelonians, that the anterior frontals are thus separated from each other; but in the *Chelys* the intervening extremities of the median frontals are continued to the upper border of the external nostril. In the present fossil cranium the oblique extremities of the anterior frontals are arrested at the distance of four lines from the nasal aperture, which is bounded above by two distinct nasal bones; these bones are joined by suture to the median frontals, to the anterior frontals, and to the superior maxillaries; the nasal processes of which extend upward, and exclude the anterior frontals from the nasal boundary. The superior maxillaries are traversed obliquely by a large and deep scutal impression, above which the superior maxillary forms a convex prominence at the anterior part of the orbit. The scutal groove which traverses the median frontals is as strongly marked; that which impresses the post-frontals is fainter. The expanded trumpet-shaped portion of the tympanic bone comes nearer the upper margin of the cavity than in existing *Chelones*.

The palatal bones have no true palatal process. The palatal processes of the intermaxillary and maxillary bones form an unusually prominent angular ridge, running nearly parallel with the trenchant margin of the jaw: the bony palate is not extended along the middle line beyond the intermaxillaries. The pterygoid bones present moderately wide and deep external emarginations.

	In.	Lin.
Length of the cranium from the occipital tubercle .	2	3
Breadth of the cranium above the tympanic cavities .	1	6
Depth of the cranium at the parietal bones	1	0
Antero-posterior diameter of the orbit	0	10
Breadth of the interorbital space	0	8

Chelone Benstedi, nob.

Emys Benstedi, Mantell.

Although very characteristic remains of Chelonian reptiles have been determined by Cuvier, from the cretaceous beds of St. Peter's Mount, near Maestricht, no evidence of the present order of Reptiles in British chalk formations had been made public until my description of a Chelonite from the lower chalk at Burham, Kent, in the museum of Sir P. Egerton, appeared in the Proceedings of the Geological Society. This Chelonite consisted of four marginal plates of the carapace, and a few other obscure fragments, sufficient to prove that the species was not *Trionyx* or *Testudo*: and as they differed in form from those of the recent species of *Chelone*, with which I compared them, and resembled rather the posterior marginal plates of some Emydians, I stated that this correspondence "rendered it probable that these remains are referable to that family of Chelonia which lives in fresh water or estuaries." Subsequent observation of the various interesting modifications by which extinct *Chelones* diminish, as it were, the gap between the marine and freshwater genera as they remain at the present day, has weakened the impression which the character of the marginal plates of the chalk Chelonite first made in favour of its Emydian affinities; and the examination of the beautiful Chelonite, obtained from the same quarries at Burham, and relieved from the chalk matrix by Mr. Bensted, lately described and figured by Dr. Mantell in the Philosophical Transactions, has demonstrated that it is not an *Emys* but a true *Chelone*.

The fossil in question consists of nearly the whole carapace, and a considerable portion of the plastron, with a coracoid bone.

The carapace includes all the dorsal or vertebral plates, save the first; the usual number of expanded ribs, viz. eight pairs; and the entire border of marginal plates, save the three first. In the sternum the hyosternal and hyposternal bones may be distinguished. The general form of the carapace is elliptical, terminated by a point at the narrower posterior end, which, however, is less contracted than in other *Chelones*. It is as depressed as in *Chelones* generally. To judge from the unmutilated vertebral plates, which are the four last, the carapace appears to have been traversed by a median longitudinal crest, from which the sides gently slope with a slight convex curvature, as in *Chelone mydas*.

The more immediate indications of the close affinity of the fossil to the marine turtles are given by the incomplete ossification and anchylosis of the ribs and sternal bones, the latter being in consequence dislocated from each other; and more especially by the shape and size of the marginal plates attached to the third, fourth, fifth, and sixth ribs, as also by the form and length of the coracoid bone.

The vertebral plates are as narrow relatively as in the ordinary *Chelones*; but their precise form can only be distinguished in the three last. The ninth*, or that to which the eighth rib is in part articulated, is 3 lines in length and 2 in breadth; the tenth expands posteriorly into a triangular form; both these have their middle part raised into a ridge; the eleventh plate is suddenly expanded, with angular sides, which slope away from a median longitudinal ridge: this is crossed by a transverse ridge just anterior to the junction of the plate with the median terminal plate of the marginal series, which is convex above and traversed by a median longitudinal furrow. The margins of this plate meet posteriorly at an open angle. The second to the seventh pairs of expanded ribs are joined together only along their vertebral halves. The length of the expanded part of the third rib is 9 lines; its narrow, tooth-like part, before it reaches the marginal plate, is also 9 lines; about 3 lines of its extremity is inserted into the deep groove of the concave surface of the marginal plate. The width of the interspace between the narrow parts of the third and fourth ribs is 4 lines; the length of the expanded part of the first rib is $10\frac{1}{2}$ lines; the breadth of the expanded part of the first rib is 8 lines; the length of the narrow end of the rib, clear of the marginal plate, is 3 lines. In the superior breadth of the first rib the *Chelone Benstedi* agrees with existing turtles, and differs strikingly from the Purbeck species. The last short rib sends, almost directly backwards, a short, narrow, tooth-like process, at right angles to the anterior margin of its sub-triangular expanded part. In *Chelone obovata* it is extended more nearly parallel with the expanded part.

The marginal plates have the same general uniformity of size which we observe in the existing *Chelones*; the posterior ones are not expanded as in the Purbeck *Chelone*, and in certain *Emydes*, as *Emys serrata*, &c.; but the most decisive evidence against the Emydian affinities of the present fossil is afforded by the form and development of the inferior borders of the marginal plates attached to the fourth, fifth, and sixth ribs; for these plates, instead of being expanded and extended inwards to join the hyo- and hyposternals, and to combine with these elements of the plastron in forming the lateral supporting wall of the carapace, are not so much developed in breadth as the same parts of the posterior marginal plates, but form with them an even free border, as in other *Chelones*, in which not any of the marginal plates are joined with the sternum.

* In all *Emydes* the proportions of this plate are the reverse of those in the fossil.

With reference to the general imperfect ossification of the carapace, the deductions in favour of the marine nature of the Chalk Chelonite might be invalidated by the hypothesis that it was the young of some very large species of *Emys*; but the existing Emydians, at the immature period when they exhibit the incomplete ossification of the carapace and plastron, have the marginal plates opposite the lateral processes of the hyosternals and hyposternals joined with those processes by an inward development of their inferior border, which is suddenly and considerably broader than the inferior border of the contiguous free marginal plates. The outer contour of the ninth, tenth, and eleventh plates projects in the form of a slight angle, and thus differs from the same parts of *Chelone mydas* and *Chelone obovata*; the others have a straight free margin. The marginal plates appear as if bent upon themselves to form their outer margin, at a rather acute angle, receiving the extremities of the rib in a depression excavated in the concavity of the angle; they are nearly twice as long in the direction parallel with the margin of the carapace than transverse to it, and are traversed in the latter direction along the middle of their upper surface with the groove or impression of the marginal scutes. The free edge of the upper plate of the marginal pieces is slightly notched above the insertion of the rib, and they correspond with those of the Chelonite from the Burham chalk-pit in the collection of Sir P. Egerton. The form of the median or vertebral scutes is only to be traced at the anterior part of the carapace, but their relative breadth and the outward extension of their lateral angles correspond, like the characters of the more enduring parts, with the type of structure of the marine turtles. The breadth of the first vertebral scute is 1 inch 8 lines, that of the second scute is 2 inches.

The coracoid bone varies in form so as to be very characteristic of the different genera of Chelonians; it is a triangular plate in *Testudo*, a more elongated triangle in *Chelys*, a broad bent elongated plate in *Trionyx*, a narrower bent plate in *Emys*, a long, straight, slender bone, slightly expanded and flattened at the sternal end, in *Chelone*: now it is precisely the latter form that this bone, fortunately preserved in the present specimen, here exhibits, showing that the same modifications of the skeleton are combined in the past as in the present species of *Chelone*; it is 1 inch 7 lines in length, cylindrical at its humeral half, and gently expanded to a breadth of 3 lines at its sternal end. The proportion which this bone presents of one-fourth the length of the carapace is only paralleled in the existing *Chelones*; it is much shorter in the *Emydes*.

The hyosternal and hyposternal bones resemble rather those of the turtles than of the young Emydes; certainly no *Emys*, with a carapace 5 inches in length, presents such forms as these bones exhibit in the present fossil; several rays or pointed spines of bone are developed from the anterior half of the median margin of the hyosternal piece, as in *Chelone caretta*; the rest of the margin contributes to form the circumference of the large central aperture of the sternum. The hyposternal sends similar rays from the posterior half of its outer margin, leaving the anterior half to join, probably the same proportion of the outer margin of the hyosternal, so as to form a deep lateral angular notch of the sternum. The length of the hyposternal is 1 inch 2 lines. The epi-, ento- and xiphisternal bones are not preserved.

From the preceding description it must be obvious, as has been already observed, that the present Chelonite of the chalk can only be supposed to belong to the genus *Emys*, on the supposition that it is a very young specimen of some unusually large species: but against this supposition, the pointed form of the hind end of the carapace, the regularity of the size of

the marginal plates, the non-development of the lower margin of any of these plates for a junction with the plastron, the narrow elongate form of the vertebral plates, and the broad vertebral scutes, collectively and separately militate; whilst in all these modifications the Turtle from the Chalk so closely corresponds with the true *Chelones*, that I cannot hesitate to refer it to the marine family of the order.

From the breadth of the xiphisternals in the remains of this species first described by me, I was induced to suppose that a new subgenus (*Cimochelys*) of marine Turtles was thereby indicated, having a closer affinity to the *Emydes* than the typical species; and the same affinity seems to be shown by the more regular elliptical form of the carapace of Mr. Bensted's beautiful specimen. The structure of the cranium, when this desirable part of the skeleton is discovered, may confirm the propriety of the subgeneric distinction; but the numerous decided marks of closer affinity to *Chelone* leave no alternative than to regard the fossil species of the chalk as a member of that genus.

It differs from all known species, especially the sub-carinated species of Sheppey, in the form of the carapace, which is more truly elliptical than in any other species with which I am acquainted.

I have been favoured with the opportunity of inspecting portions of the skeleton of a large Chelonian obtained by Mrs. Smith, of Tonbridge Wells, from the lower chalk at Burham, Kent, and skilfully relieved from their mineral bed by that lady. The principal bones consist of two series, one containing five, the other four, of the marginal plates of the carapace, in natural connection, and from that part of the margin where they receive the extremities of the vertebral ribs. These marginal plates in *Chelone mydas* are three-sided, and have two terminal surfaces by which they are united, suturally, to one another: of the three free surfaces, the one, directed towards the interior of the body, is characterized by a deep depression for the reception of the tooth-like extremity of the rib; the two other (upper and under) surfaces meet at an angle, which is produced at certain parts to form the marginal dentations of the lateral and posterior parts of the carapace in that species of turtle, but is more open and obtuse in the marginal plates at the anterior part of the carapace. In the fossil the marginal plates have the general characters of those of the genus *Chelone*, but differ from those of the *Chelone mydas*, in being more concave on the central or perforated side, and they are also concave at the upper side, and in a slighter degree at the under side; these sides likewise meet at a more acute angle, and this angle is produced into a sharper and more continuous ridge: but this ridge subsides at one end of the series of five plates, and the upper and under sides gradually meet at a more open angle, which is rounded off in the first of the series. This plate, therefore, answers to the third marginal plate in the *Chelone mydas*, or that which receives the end of the first expanded vertebral rib; and the remainder, therefore, to the fourth, fifth, sixth, and seventh marginal plates: now these are precisely the marginal plates in the *Emys*, which have their inferior margins developed inwards and articulated by suture to the lateral wall of the carapace: but these margins not being so developed or terminated in the present fossil, but, on the contrary, being inferior to the upper margin in breadth*, and terminating like that margin in a blunted edge, prove the present Chelonite to belong, like the smaller Chelonite from the same chalk-pit already described, to the marine genus *Chelone*.

The following admeasurements will show the different proportions of the

* The upper margin, which is distinguished by a slight notch where the costal groove leads to the pit, is broader than the lower one, in these plates of the *Chelone mydas*; but the difference is less than in the present fossil species.

marginal plates of the present specimen as compared with the corresponding ones of a *Chelone mydas* of similar general size:—

	Fossil Chel. In.	Lin.	*Chel. mydas.* In.	Lin.
Length of the series of five plates in a straight line	7	3	8	2
Breadth of the upper surface of the third (fifth) .	1	1	0	10
Interspace of costal depressions	1	2	1	6

Thus the marginal plates of the chalk turtle, besides being more concave, are broader in proportion to their length, or antero-posterior diameter. In these respects they correspond with the form of the marginal plates in the *Chelone Benstedi*, and most probably belong to a larger and older specimen of the same species.

There are two other marginal plates imbedded in the same portion of chalk, with their upper, smooth, slightly concave surfaces exposed; and the toothed or sternal extremities of three of the vertebral ribs, which by their length and size also prove this specimen to be a turtle. One of these fragments of rib measures $5\frac{1}{2}$ inches, and the expanded plates developed from each side of its upper surface are concave on their exterior surface, which is flat or slightly convex in *Chelone mydas*.

A separate portion of chalk from the same pit contains the scapula and its acromial branch or anchylosed clavicle, with the articular surface which joins with the coracoid and humerus. The angle at which the scapula and clavicle meet is more open in *Chelone* than in *Emys* or *Chelys*: the present specimen presents the same angle as in the Maestricht *Chelone* figured by Cuvier *, in which it is rather more open than in the recent species of turtle. A broad, thin, slightly concave plate of bone appears, by the radiation of the fine striæ at its under part, to represent the expanded parietal bone of the cranium.

The carapace of the turtle to which the fragments above described belonged, must have been nearly if not quite two feet in length.

Eocene Tertiary Chelones.—Although both the leading divisions of freshwater Chelonians are represented in the Eocene tertiary formations of Great Britain, the one by the *Emys testudiniformis*, the other by the *Platemys* or *Hydraspis Bullockii*, the Chelonian Reptiles from the London clay of Sheppey and Harwich are for the most part true turtles, or species of the genus *Chelone*. Already good evidence of at least five distinct species have been obtained from these localities, and it is probable that others remain to be discovered; they are generally of smaller size than the species which are now restricted to warmer or intertropical latitudes, and differ from those species, as well as from each other, by well-marked characters afforded by the skull, the carapace, and the plastron.

Chelone longiceps.—The most common species, *Chelone longiceps*†, is distinguished by very interesting modifications both of the cranium and osseous buckler, by which it approaches more nearly to the freshwater Chelonians than do any of the existing species of *Chelone*. In the prolongation of the conical rostrum and osseous palate, the skull of this species resembles that of a *Trionyx*, but the temporal fossæ are covered by a roof of bone having the characteristic anatomical structure of the true *Chelones*. The buckler is broader in proportion, and both carapace and plastron are more completely ossified than in recent turtles; thus both the hyosternals and hyposternals are broader

* Ossem. Foss., tom. v. part ii. pl. xiv. fig. 5.

† The characters of this and the other species of *Chelone* from the London clay formation are detailed in my Memoir on that subject read before the Geological Society, Dec. 1, 1841.

than they are long; the xiphisternals are unusually broad. The tooth-like processes from the mesial margins of the hyo- and hyposternals are more numerous and smaller than in existing species, and interlock with each other, so that two margins of each of these bones are joined by suture, instead of one, as in almost all other turtles. Yet in the largest specimens of this species which I have seen, the centre of the sternum remains unossified, its sides ununited by bone with the carapace, and the external and part of the internal margins of its constituent bones preserve their separated tooth-like rays.

The small specimen of which the plastron is figured by Parkinson and by Cuvier, belongs to the present species of *Chelone*; it is now preserved in the rich collection of Prof. Bell. In the same collection there is preserved a specimen of *Chelone longiceps*, the plastron of which is 8 inches in length and nearly 8 inches in breadth; in this specimen, which is the largest of the present species that I have seen, the central vacuity of the plastron and the toothed margins of many of the constituent bones remain. Three of the Chelonites in the museum of Sir P. Egerton, two in that of Mr. Bowerbank, one in that of Mr. Dixon, and one in the Hunterian Collection, belong to the *Chelone longiceps*. All these specimens are from the Isle of Sheppey.

Chelone planimentum, nob.—The species which, in the number of individuals representing it comes next in order after the *Chelone longiceps*, is characterized by a flat and unusually long symphysis of the lower jaw, but this is associated with a broad, high, and convex cranium, and with a muzzle not longer than in ordinary *Chelones*. The carapace is characterized by the strength of the ribs which traverse the whole of the under part of the expanded plates in the form of thick convex ridges.

All the specimens of this species that I have hitherto seen are from the Eocene clay of the eastern coast of Essex. A carapace in the British Museum measures 13 inches in length and 12 inches across the fourth pair of expanded ribs. A skull in the museum of Prof. Sedgwick, associated with a carapace and other parts of the skeleton of the same individual, and another skull in that of Prof. Bell, indicate that the head was relatively as large in the *Chelone planimentum* as in the *Chelone imbricata*.

Chelone breviceps, nob.—This species, in the narrow, ovate, and posteriorly pointed carapace, and in the less extensive ossification of the sternum, resembles more the recent *Chelones* than does the *Chelone longiceps*. Its cranium also preserves the ordinary form in its depth and in the shortness of its muzzle. The external surface of the cranium and osseous buckler is rugous. The angles by which the expanded ribs are wedged into the interspaces of the vertebral plates have equal or nearly equal sides. It appears to have exceeded the *Chelone longiceps* in size: a portion of the osseous buckler of a *Chelone breviceps*, with a carapace 16 inches in length, is preserved in the museum of Mr. Robertson, surgeon, at Chatham.

Smaller specimens of the *Chelone breviceps*, all from the Isle of Sheppey are preserved in the Hunterian Collection, in the museum of Prof. Bell, and in that of Mr. Bowerbank. Mr. Bowerbank's specimen exhibits the head in connection with the carapace and plastron, and is the most beautiful Chelonite, perhaps, that has yet been obtained from any formation.

Chelone convexa, nob.—The surface of the bony buckler of this species, like that of the *Chelone longiceps*, is smooth, but the forms of the constituent bones of the carapace and their degree of ossification differ considerably from those of a *Chelone longiceps* of the same size, and resemble those of *Chelone mydas*. The carapace is more convex than in the *preceding species* from Sheppey, and than in the existing *Chelones*, whence the specific name of the present extinct species. It is from the Isle of Sheppey.

Chelone suberistata, nob.—This species, also from the Isle of Sheppey, has the usual thalassian form of carapace, which is narrow, ovate, and contracted to a point behind, with a sternum resembling also existing *Chelones*, in the form and degree of ossification of its constituent pieces, and the slenderness of the xiphisternals. It may be distinguished from the *Chelone breviceps* by the smoothness of its carapace, the different form of the vertebral plates, and the development of a sharp ridge on the sixth and eighth vertebral plates.

The sole example of this species which has come under my observation is the osseous buckler, 9 inches in length and $6\frac{1}{2}$ inches in breadth, in the museum of Mr. Bowerbank.

Chelone latiscutata, nob.—This species is founded on a nearly complete buckler of a turtle from Sheppey, measuring 3 inches in length, from the second to the seventh plate inclusive: it may be a variety, or the immature state of *Chelone longiceps*, but I have not yet had the opportunity of ascertaining to what extent the relative breadth of the vertebral scutes varies in individuals of different age of existing species of turtle. In the present case the vertebral scutes are nearly twice as broad in proportion to their length, as they are in the *Chelone longiceps*, or in any of the other well-marked species of Eocene turtles.

The indications of Chelonites from Eocene strata, in the works of Parkinson, Woodward and König, being unaccompanied by the anatomical deductions essential to the establishment of their true affinities, have been either misinterpreted or neglected; and except the citation of Woodward's *Chelone Harvicensis*, in M. H. v. Meyer's Compilation*, the existence in the London clay of fossil *Emydes* alone has been recognized in the latest summaries of the present branch of Palæontology†. These, therefore, could indicate but little difference between the present fauna and that of the Eocene period in regard to the Chelonian order. But the case assumes a very different aspect when we arrive at the conviction that the majority of Sheppey Chelonites belong to the marine genus *Chelone*, and reflect that the number of extinct Eocene turtles from that limited locality very nearly equals that of all the well-determined species of *Chelone* now known to exist. For notwithstanding the assiduous search of the naturalist-collector, and the attractions which the shell and flesh of turtles offer to the commercial voyager, the tropical seas, though so often traversed, have not as yet yielded more than five good species of *Chelone*; and of these only two, as *Chelone mydas* and *Chelone caretta*, are known to frequent the same locality. Now, whilst it is obvious that but a small proportion of the organized treasures of the vast deposit of petrified mud and clay which fills the London Basin have been brought to light, the results of the examination of fossil Chelonites evidently show that the ancient ocean of the Eocene epoch was more abundantly provided with turtles, and that these presented a greater variety of specific modifications than the same extent of ocean in any of the warmer parts of the earth at the present day.

The indications which the Sheppey turtles give, in conjunction with the other organic remains from the same depository, of the higher temperature that prevailed in the latitude in which they lived, cannot be overlooked; yet at the same time the conditions, which allow of the attainment of the size which the present tropical turtles often exhibit, would seem not to have been present in the time and place of existence of the extinct species of *Chelone*

* Palæologica, p. 104.

† See Cuvier, Ossem. Fossiles, ed. 1836, 8vo, tom. ix. p. 464; Buckland, Bridgewater Treatise, vol. i. p. 258; the recent comprehensive work on Erpetology, by MM. Dumeril and Bibron, tom. ii. p. 533; and Dr. Grant in the British Annual for 1839, p. 266.

above enumerated; and again, the affinities to the freshwater forms which the skeleton of some of the Eocene *Chelones* exhibit, accord with the indications that they inhabited the estuary of a great river.

Order OPHIDIA.

In the Appendix to the second 4to edition of the 'Ossemens Fossiles,' Cuvier remarks, "Les os de serpens sont encore plus rares, s'il est possible. Je n'en ai vu que des vertèbres des brèches osseuses de Cette, dont j'ai parlé à l'article de ces brèches, et une seule des terrains d'eau douce de l'île de Sheppey*."

The Ophidiolites from this formation have been the subject of a memoir by me, published in the sixth volume (second series) of the Geological Transactions, in which the best-preserved specimens in the collections of John Hunter and Mr. Bowerbank are described. The Hunterian Ophidiolites were referred by the Founder of the collection, in the original MS. Catalogue, to the Crocodile; some of those in the private collections I found ticketed "Vertebræ of Tortoise." All these specimens presented the general characteristics of the vertebræ of serpents, and resembled in structure as well as size those of the Constrictors (*Python* and *Boa*) more than those of the colubrine or poisonous families. Very recognizable differences are to be discerned in the Eocene fossil vertebræ as compared with the vertebræ of existing Pythons and Boæ; they are longer as compared with their height or breadth; the costal tubercle is placed lower down; the transverse process supporting the lower anterior articular process has a greater vertical extent, and the ridge continued from the lower anterior to the lower posterior oblique process is less developed; the oblique processes do not extend so far outwards, and the spinous process is higher, but has a less antero-posterior extent than in existing land-serpents. The middle of the posterior margin of the neurapophysis, opposite the external angle of the articular excavation or mortise, is produced backwards in the form of an angular plate. The inferior surface of the vertebra is not longitudinally carinated, as in some *Colubri*, but has a tubercle at the middle of the anterior part, as in the *Python*.

These differences justify the consideration of the Sheppey Ophidiolite as the representative of a distinct genus as well as species, for which I have proposed the name of *Palæophis toliapicus*.

The largest of the Ophidiolites in Mr. Bowerbank's collection exhibits a portion of the vertebral column suddenly bent upon itself, including about thirty vertebræ, and indicating the usual lateral flexibility of the spine. The Hunterian specimen also consists of a group of as many vertebræ more disjointed, and cemented, with a number of long and slender ribs, irregularly together by a mass of indurated clay. In the museum of Mr. Saull a few vertebræ, and a fragment of the skull of the same *Palæophis*, likewise from Sheppey, are preserved. The size of the vertebræ in the foregoing specimens corresponds with that of the vertebræ of a boa constrictor of 10 or 12 feet in length.

Vertebræ of a serpent agreeing in character with those of the London clay at Sheppey, but smaller, have been obtained by Mr. Colchester, from the sand of the Eocene formation underlying the Red Crag at Kyson or Kingston in Suffolk. These have also the small tubercle at the under and back part of the body of the vertebra, instead of the ridge, as in *Coluber* and *Naja*; and thus, like the larger vertebræ from Sheppey, they come nearer to the *Python*; but the bodies of these vertebræ are longer in proportion to their breadth, as in the Sheppey *Palæophis*. The tubercle for the rib is

* Tom. v. part ii. p. 526.

single; in *Naja* it is almost divided into two, the upper being convex, the lower moiety concave; in the *Python* the upper half of the tubercle is convex and the lower half concave, but the two facets are not marked off. In the *Palæophis*, of both Sheppey and Kyson, it is simply convex.

The most perfectly preserved, as well as the largest specimens of vertebræ of *Palæophis* which I have seen, are from the Eocene clay at Bracklesham, and are preserved in the select collection of Fr. Dixon, Esq. of Worthing. The serpent to which the largest of these vertebræ belonged must have been upwards of 20 feet in length.

Ophidian reptiles, of ten, twelve, and twenty feet in length, exist in the present day only in intertropical regions, and they for the most part prey on mammals and birds. If, therefore, direct evidence of species of both these warm-blooded classes in the London clay had not been obtained*, they might have been strongly suspected to have co-existed with serpents of such dimensions as those to which the vertebræ and ribs above mentioned belonged.

Order BATRACHIA.

Of this order of Reptiles, represented in the present Fauna of Great Britain by a few diminutive species of frogs, toads, and newts, the remains of some remarkable extinct members have been discovered in the New Red Sandstone of Warwickshire.

As the determination of these fragments has been the result of the examination, in part microscopical, of detached bones and fragments of bone and teeth, and since the Batrachian order, like most others at the confines of a great natural group, exhibits wide modifications of its typical structure, a few words may be expected touching the grounds for referring the fossils in question to the Batrachian order, especially since similar fossils in another country, specimens of the same species, have been regarded as parts of Saurians.

The Batrachians have no fixed type of external form like the higher orders of Reptiles, but some, as the broad and flat-bodied toads and frogs, most resemble the Chelonians, especially the soft-skinned mud-tortoises (*Trionyx*); other Batrachians, as the *Cæciliæ*, resemble Ophidians; a third group, as the Newts and Salamanders, represent the Lacertians; and among the Perennibranchiate reptiles there are species which combine with external gills the mutilated condition of the apodal fishes.

Thus it will be perceived, that, even if the entire skeleton of one of the New Red Sandstone Batrachians had been obtained, there is no fixed or characteristic general outward form in the Batrachian order whereby its affinity to that group could have been determined. The common characters by which the Batrachians, so diversified in other respects, are naturally associated into one group or suborder of reptiles, besides being taken from the condition of the circulating and generative systems and other perishable parts, are, however, fortunately as strongly manifested in modifications of the skeleton and principally in the skull. This is joined to the atlas by the medium of two tubercles, developed exclusively from the lateral occipitals; the bony palate is formed chiefly by two broad and flat bones, called 'vomerine' by Cuvier, and generally supporting teeth. It is only in the Batrachians among reptiles that examples are found of two or more rows of teeth on the same bone, especially on the lower jaw (*Cæciliæ*, *Sirenes*). With regard to vertebral characters, no such absolute Batrachian modifications can be adduced as those above cited from the anatomy of the cranium. Some Batrachians, as is well known, have the vertebræ united by ball-and-socket joints, as in most recent

* Geological Transactions, second series, vol. vi. p. 203, pl. 21.

reptiles; others by biconcave joints, as in a few recent and most extinct Saurians. Some species have ribs, others want those appendages; the possession of ribs, therefore, even if longer than those of the *Cæciliæ*, by a fossil reptile combining all the essential Batrachian characters of the skull, would not be sufficient ground for pronouncing such reptile to be a Saurian. Much less could its Saurian nature be pronounced from the circumstance of its possessing large conical striated teeth; as the ordinary characters of size, form, number, and even presence or absence of teeth, varies much in existing Batrachians, the location of teeth on the vomerine bones being the only constant dental character in which they differ from all other orders of reptiles.

My first acquaintance with the remarkable fossils under consideration was founded on the examination of portions of teeth, from the new red sandstone of Coton End quarry, Warwickshire, transmitted to me by Dr. Lloyd of Leamington. The external characters of these teeth corresponded with those which had previously been discovered, by Prof. Jaeger, in the German Keuper formation in Wirtemberg, and on which the genus *Mastodonsaurus* had been found.

The results of a microscopic examination of the teeth of the *Mastodonsaurus* from the German Keuper, and of those from the New Red Sandstone of Warwickshire, have been detailed in the Proceedings of the Geological Society, January 1841, and illustrated in my 'Odontography,' pp. 195—217, pls. 63, 63 A, 63 B, 64, 64 A, 64 B. They proved that the teeth from both localities possessed in common a very remarkable and complicated structure, to the principle of which, viz. the convergence of numerous inflected folds of the external layer of cement towards the pulp-cavity, a very slight approach was made in the fang of the tooth of the *Ichthyosaurus*, and that a closer approximation to the labyrinthine structure in question was made by the teeth of several species of fishes, while the teeth of existing Batrachians were simple, like those of most Saurians.

Thus, inasmuch as the extinct animal in question manifested in the intimate structure of its teeth an affinity to fishes, it might be expected that, if it actually belonged to the class of reptiles, the rest of its structure would manifest the characters of the lowest order, viz. the *Batrachia*, the existing members of which pass, though not by the dental character alluded to, yet by so many other remarkable degradations of structure, towards fishes. Now it has actually happened that, in the same formation in Wirtemberg from which the labyrinthic teeth of the so-called *Mastodonsaurus* have been derived, a fragment of the posterior portion of the skull has been obtained, showing the apparent absence of the basi-occipital, and the development of a separate condyle on each ex-occipital bone; whence Prof. Jaeger, recognizing the identity of this structure with the Batrachian character above mentioned, founded upon the fossil a new genus of *Batrachia*, which he called '*Salamandroides giganteus*.' Subsequent discoveries, however, satisfied the Professor that the bi-condylous fragment of skull, representing the genus *Salamandroides*, belonged to the same reptile as the teeth, on which he had founded the genus *Mastodonsaurus*. But notwithstanding the evidence thus obtained of the Batrachian affinities of the Keuper Reptile, Prof. Jaeger preferred to retain for it the name which implied its membership with the Saurian order, and cancelled the genus *Salamandroides*, which form of substantive has, indeed, been forbidden by the canons of botanical nomenclature to be used as the name of a genus*.

I proceed now briefly to notice the fossils from the Warwick sandstone

* "Nomina generica in *oïdes* desinentia e foro Botanico relegenda sunt."—Linnæi Philosophia Botanica, 1751, p. 161.

described in my Memoir read before the Geological Society, and in which additional, and, as it seems to me, conclusive proof is given of the Batrachian nature of the genus to which those fossils belong; with the establishment of five distinct species, one of which is most probably identical with the *Mastodonsaurus salamandroides* of Prof. Jaeger.

It is scarcely necessary to repeat the reasons which I have given to show that the generic denomination *Mastodonsaurus* cannot be retained; first, it unavoidably recalls the idea of the mammalian genus *Mastodon*, or else a mammilloid form of tooth, whereas, all the teeth of the reptile so called are originally, and most of them are permanently of a cuspidate and not of a mammilloid form; secondly, because the second element of the word, *saurus*, indicates the genus to belong to the Saurian and not to the Batrachian order of reptiles. For these reasons I have proposed to designate the genus in question *Labyrinthodon*, in allusion to the peculiar and characteristic structure of the teeth.

The specimens which I have examined are referable to five species, viz. 1. *Labyrinthodon salamandroides*; 2. *L. leptognathus*; 3. *L. pachygnathus*; 4. *L. ventricosus*; and 5. *L. scutulatus*: and I shall here briefly notice the characters exhibited by the bones assignable to the 2nd, 3rd, and 5th species.

Labyrinthodon leptognathus.—The remains which I consider as portions of this species, consist of fragments of the upper and lower jaws, two vertebræ, and a sternum. They were found in the sandstone quarries at Coton End, near Warwick.

The portions of the upper jaw show that the maxillary or facial division of the skull was broad, much depressed, and flattened, resembling the skull of the gigantic Salamander and of the Alligator; and the outer surface of the bones was strongly sculptured, as in the Crocodilian family, but of a relatively larger and coarser pattern. One portion of the upper jaw contains the anterior moiety of the single row of small teeth, or thirty sockets, and the base of one of the great anterior tusks. The bases of the serial teeth project directly from the outer wall of the shallow socket, there being no alveolar ridge external to it. The large anterior fang is three times the size of the first of the serial teeth, and the size of these gradually diminishes as they are placed further back; the length of the common-sized teeth being about two lines, and the greatest breadth one-third of a line. The apical two-thirds of each tooth is smooth, but the basal third is fluted, and anchylosed to the outer wall of the socket. The breadth of the upper jaw, opposite the middle of the dental series, was two inches six lines; in proceeding backwards the jaw gradually expands to three inches, and in proceeding forwards narrows, but in a less degree towards the anterior extremity, and then slightly widens or inclines outwards on account of the large tusks. Where the upper jaw is entire, a portion next the median suture, four lines in breadth, is separated from the maxillary bone by a longitudinal harmonia, and corresponds with the position of the nasal bone in the Crocodile.

On comparing the structure of the cranium of the *Labyrinthodon* with the existing Batrachians, it is true that an important modification will be found to exist. In both the caducibranchiate and perennibranchiate species, the upper maxillary bones do not extend horizontally over the upper surface of the skull, but leave a very wide interval between the maxillary and nasal bones; and the palatal processes of the former contribute as little to form the floor of the nasal cavity: in the Crocodiles, on the contrary, the palatal processes of the maxillary bones extend horizontally inwards, and meet at the middle line of the roof, forming an unbroken floor to the nasal cavity. In the *Labyrinthodon* the superior maxillary bones, as already shown, extend inwards to the nasal bone, constituting with it a continuous roof to the nasal

cavities; but the palatal processes, instead of reaching to the middle line, as in the Crocodiles, are very narrow, as in the *Batrachia*. The osseous roof of the mouth is principally composed of a pair of broad and flat bones, analogous to the divided vomer in *Batrachia*, but of much greater relative extent, approaching, in this respect, those of the Menopome, and defending the mouth with a more extensive roof of bone than exists in any Lacertian reptile: physiologically, therefore, the *Labyrinthodon*, in this part of its structure, comes nearest to the Crocodile; but the structure itself, morphologically, is essentially Batrachian. In the Menopome and gigantic Salamander, a row of small teeth extends transversely across the anterior extremity of the vomerine bones: and the occurrence in the *Labyrinthodon* of a similar row, consisting in each palatine bone of three median small teeth and two outer larger ones, marks most strongly its Batrachian nature; and from the outermost tooth a longitudinal row of small and equal-sized teeth is continued backward along the exterior margin of the palatine bone. The whole of this series of palatal teeth is nearly concentric with the maxillary teeth.

In Lacertine reptiles the examples of a row of palatal teeth are rare, and, when present, it is short, and situated towards the back of the palate, upon the pterygoid bones, as in the Iguana and Mosasaur. In Batrachians the most common disposition of the palatal teeth is a transverse row placed at the anterior part of the divided vomer, as in Frogs, the Menopome and gigantic Salamander, and at the posterior part in certain toads. In the Amphiume, on the contrary, the palatal teeth form a nearly longitudinal series along the outer margin of the vomerine bones. The *Labyrinthodon* combines both these dispositions of the palatal teeth, which are arranged transversely across the fore part of the divided vomer and extend backwards along its outer margin. No teeth are placed on the pterygoid bones at the back of the palate as in the Saurians with palatal teeth. The posterior palatine apertures are, however, more completely circumscribed by bone than in most Batrachians, and occupy the same relative position as in the Iguana. The posterior margin only of one of the anterior apertures is exhibited in the specimen here described, but from its curve I infer that the two apertures are not confluent, as in the Crocodile, the Frog, or the Menopome, but that they are distant, as in the Iguana.

From the physiological condition of the nasal cavity it may be concluded that the *Labyrinthodon* differed from the Batrachians and resembled the Saurians in having distinct posterior nasal apertures surrounded by bone, and that its mode of respiration was the same as in the higher air-breathing reptiles. In the shedding and renewal of the maxillary and the transverse palatal teeth, it is evident that the process took place alternately in each row, as in many fishes, whereby the dental series was always kept in an efficient state.

Another instructive fossil is a portion of the left ramus of an under jaw of *Labyrinthodon leptognathus* from the Warwick sandstone. It is six inches long, slender and straight, the symphysial extremity is abruptly bent inwards, and it presents almost as striking a Batrachian character as any of the bones just mentioned. The angular piece is of great breadth, and is continued forward to near the symphysis, forming the whole of the inferior part of the jaw, and extending upon the inner as far as upon the outer side of the ramus, the inner plate performing the function of the detached os operculare in the jaw of Saurians. The dentary bone is supported upon a deep and wide groove along the upper surface of the angular piece, which also projects beyond the groove, so as to form a strong convex ridge on the external side of the jaw, below the dentary piece. This character, which in the large bull-frog (*Rana pipiens*) is confined to the posterior part of the maxillary ramus, is in the *Labyrinthodon* continued to near the anterior extremity. The teeth

are long and slender, gradually diminishing in size towards the anterior portion of the jaw, and the fragment presents a linear series of not less than fifty sockets, placed alternately a little more internally; and at the anterior inflected part of the jaw is the base of the socket of a large tooth. The anterior portion of the jaw being broken off, it is uncertain if the serial teeth were continued externally to the anterior tusk, which is a remarkable ichthyoid character noticed in another species of *Labyrinthodon*.

The sockets of the teeth are shallower than in the upper jaw; the outer wall is more developed than the inner, and the anchylosed bases of the teeth more nearly resemble, in their oblique position, those of existing *Batrachia*. With regard to the modification of the microscopic structure of the teeth, I may observe that, between the apex and the part where the inflected vertical folds of the cement commence, the tooth resembles, in the simplicity of its intimate structure, that of the entire tooth of ordinary *Batrachia* and most reptiles; and in the lower or basal half of the tooth the structure described in the works before quoted commences, and gradually increases in complexity.

From the long and slender character of this ramus, the length of the head, as compared with the breadth, approximates more nearly to Crocodilian proportions than to the ordinary Batrachian ones; but among existing Batrachia it resembles most nearly the Amphiume.

A dorsal vertebra from Coton End presents further evidence of the Batrachian nature of the *Labyrinthodon*. It has concave articular cavities at the extremities of the body, a condition now known, among existing reptiles, only in the Geckos, and in the lower or perennibranchiate division of Batrachians. It is a common structure in extinct Saurians, but the depth of the vertebral articular cavities in the *Labyrinthodon* exceeds that in the Amphicœlian Crocodilians and in most Plesiosaurs. The body of the vertebra is elongate and subcompressed, with a smooth but not regularly curved lateral surface, terminating below in a slightly produced, longitudinal, median ridge; and it exhibits the same exceptional condition in the Reptilian class as do the vertebræ of existing Batrachians, in having the superior arch or neurapophysis anchylosed with the centrum. From each side of the base of the neural arch a thick and strong transverse process extends obliquely outwards and upwards.

A symmetrical bone, resembling the episternum of the *Ichthyosaurus*, was associated with the preceding remains. It consists of a stem or middle, which gradually thickens to the upper end, where cross-pieces are given off at right angles to the stem, and support on each a pretty deep and wide groove indicating strongly the presence of clavicles, and thus pointing out another distinction from Crocodiles, in which clavicles are wanting. Most Batrachians possess these bones.

The modifications of the jaws, and more especially those of the bony palate of the *Labyrinthodon leptognathus*, prove the fossil to have been essentially Batrachian, but with affinities to the higher Sauria, leading, in the form of the skull and the sculpturing of the cranial bones, to the Crocodilian group, in the collocation of the larger fangs at the anterior extremities of the jaws to the *Plesiosaurus*, and in one part of the dental structure, in the form of the episternum, and the biconcave vertebræ, to the *Ichthyosaurus*. Another marked peculiarity in this fossil is the anchylosis of the base of the teeth to distinct and shallow sockets, by which it is made to resemble the Sphyræna and certain other fishes. From the absence of any trace of excavation at the inner side of the base of the functional teeth, or of alveoli of reserve for the successional teeth, it may be concluded that the teeth were reproduced, as in the lower Batrachians and in many fishes, especially the higher Chondropterygii, which formed the *Amphibia Nantes* of Linnæus, in the soft mucous membrane which covered the alveolar margin, and that they subsequently became

fixed to the bone by anchylosis, as in the Pike and Lophius. This anatomical fact militates strongly against the idea that the *Labyrinthodon* is a Saurian*. No remains of the locomotive organs of the *L. leptognathus* have yet been found.

Labyrinthodon pachygnathus.—The remains of this species, which have been obtained, consist of portions of the lower and upper jaws, an anterior frontal bone, a fractured humerus, an ilium with a great part of the acetabulum, the head of a femur, and two ungual phalanges. A portion, nine and a half inches long, of a right ramus of a lower jaw, in addition to the characters common to it and the fragment of the lower jaw of the *L. leptognathus*, in the structure of the angular and dentary pieces, shows that the outer wall of the alveolar process is not higher than the inner, as in Frogs and Toads, the Salamanders and Menopome, in all of which the base of the teeth is anchylosed to the inner side of an external alveolar plate. The smaller serial teeth are about forty in number, and gradually diminish in size as they approach both ends, but chiefly so towards the anterior part of the jaw. The sockets are close together, and the alternate ones are empty. The great laniary teeth were apparently three in each symphysis, and the length of the largest is considered to have been one and a half inch. A section through the base of the anterior tusk above the socket exhibits the structure described in the Proceedings of the Geological Society, January, 1841, but a section of the second tusk, also taken above the socket, shows a less complex modification of the labyrinthic arrangement, one, viz. which is closely analogous to that at the base of the teeth of the *Ichthyosaurus*. The apical half of the tusks has a smooth and polished surface, and the pulp-cavity is continued, of small size, into the centre of this part of the tooth. In the serial teeth, which in other respects, except size, correspond with the preceding description of the tusks, the central pulp-cavity is more quickly obliterated, but the alveoli are large, moderately deep and complete: the texture of the teeth is dense and brittle. The base of each tooth is anchylosed to the bottom of its socket, as in Scomberoid and Sauroid fishes; but the *Labyrinthodon* possesses a still more ichthyic character in the continuation, preserved in this specimen, of a row of small teeth anterior and external to the two or three larger tusks. A double row of teeth thus occasioned does not exist in the maxillary bones, either superior or inferior, of any Saurian reptile†; but in Batrachia it has been noticed in the lower jaw of the *Cæcilia*, and it is not an uncommon structure in fishes.

A fragment of the superior maxillary bone manifests a striking deviation from the Crocodilian type of structure in the continuation of the palatal plate of the intermaxillary bone for about an inch to the outer side of the base of the external plate or process; while in the Crocodiles the external wall of the intermaxillary bone is united by the whole of its outer margin with the maxillary, and is thence continued along the whole outer contour of the intermaxillary bone. Now in the *Labyrinthodon* the intermaxillary bone presents the same peculiar modification of the Batrachian condition of this bone as in the higher organized Batrachia, the palatal process of the intermaxillary extending beyond the outer plate both externally and, though in a less degree, internally, where it forms part of the boundary of the anterior palatal foramen, whence the outer plate rises in the form of a compressed process from a longitudinal tract in the upper part of the palatal process; it is here broken off near its margin, and the fractured surface gives the breadth of the base of the outer

* It would be highly desirable to determine in how many of the characters above detailed the *Nothosaurus mirabilis*, Muenster, may deviate, like the *Labyrinthodon*, from the Saurian type of structure: it would seem to connect the *Plesiosaurus* with the *Labyrinthodon*.

† The successional teeth in *Plesiosaurus* and *Nothosaurus* are sometimes so far developed before they displace their predecessors as to cause the appearance of a double row.

plate, stamping the fossil with a Batrachian character conspicuous above all the Saurian modifications by which the essential nature of the fossil appears at first sight to be masked.

In the anterior frontal bone there are indications of Crocodilian structure. Its superior surface is slightly convex and pitted with irregular impressions; and from its posterior and outer part it sends downwards a broad and slightly concave process, which appears to be the anterior boundary of the orbit. This process presents near its upper margin a deep pit, from which a groove is continued forwards; and in the corresponding orbital plate of the Crocodile there is a similar but smaller foramen.

From these remains of the cranium of the *Lab. pachygnathus*, it is evident that the facial or maxillary part of the skull was formed in the main after the Crocodilian type, but with well-marked Batrachian modifications in the intermaxillary and inferior maxillary bones. The most important fact which they show is, that this Sauroid Batrachian had subterminal nostrils, leading to a wide and shallow nasal cavity, separated by a broad and almost continuous palatal flooring f om the cavity of the mouth; indicating, with their horizontal position, that their posterior apertures were placed far behind the anterior or external nostrils; whereas in the air-breathing Batrachia the nasal meatus is short and vertical, and the internal apertures pierce the anterior part of the palate. It may be inferred, therefore, that the apparatus for breathing by inspiration must have been present in the *Labyrinthodon* as in the Crocodile; and hence still further, that the skeleton of the *Labyrinthodon* will be found to be provided with well-developed costal ribs, and not, as in most of the existing Batrachians, with merely rudimentary styles. Since the essential condition of this defective state of the ribs of Batrachians is well known to be their fish-like mode of generation and necessary distension of the abdomen, it is probable that the generative economy of these fossil reptiles, in which the more complete ribs would prevent the excessive enlargement of the ovaria and oviducts, may have been similar to that of Saurian reptiles.

A fragment of a vertebra of *Lab. pachygnathus* presents analogous characters to the vertebra of the *Lab. leptognathus* previously noticed.

Of the few bones of the extremities which have come under my inspection, one presents all the characteristics of the corresponding part of the humerus of a toad or frog, viz. the convex, somewhat transversely extended articular end, the internal longitudinal depression, and the well-developed deltoid ridge. The length of the fragment is two inches, and the breadth is thirteen lines. The ridges are moderately thick and compact, with a central medullary cavity. In its structure as well as in its general form, the present bone agrees with the Batrachian, and differs from the Crocodilian type.

In the right ilium, about six inches in length, and in the acetabulum, there is a combination of Crocodilian and Batrachian characters. The acetabular cavity is bounded on its upper part by a produced and sharp ridge, as in the frog; and not emarginate at its anterior part, as in the crocodile. Above the acetabulum in the frog the ilium gives off a broad and depressed process, the lower extremity of which is separated from the acetabulum by a smooth concave groove, both of which are wanting in the crocodile, there being only a slight rising of the upper border of the acetabulum. These characters, however, are well developed in the *Labyrinthodon*: but the process, instead of being depressed, is compressed, and its internal extremity is pointed and bent forwards, representing the rudiment of the long anterior process of the ilium in the *Batrachia anoura*; but it does not attain in the *Labyrinthodon* the parallel of the anterior margin of the acetabulum, and the bone terminates in a thick truncated extremity a few lines anterior to the acetabulum; which gives an essential feature of resemblance to the Crocodiles and difference from the

Batrachians. But the most marked difference in this fossil from the crocodile is the length of the ilium posterior to the acetabulum, in which it agrees with the analogous portion of the frog and other tailless Batrachians; while, on the contrary, there is an agreement with the Crocodilian type in the mode of articulation to the vertebral column. In the frog a transverse process of a single vertebra abuts against the anterior extremity of the produced ilium. In the crocodile the transverse processes of two vertebræ are thickened and expanded, and joined to a rough, concave, articular surface occupying the inner side of the ilium, and a little posterior to the acetabular cavity. In the *Labyrinthodon* is a similar well-marked, rough, elongated, concave, articular surface, divided by a non-articular surface, and destined for the reception of the external extremities of two sacral ribs. The *Labyrinthodon* likewise agrees with the crocodile in the lower part of the acetabulum being completed by the upper extremity of the pubis, the anterior and inferior part of the ilium offering an obtuse process at the posterior part of the lower boundary of the acetabular cavity.

As the fragment of the ilium was discovered in the same quarry as the two fragments of the cranium and the portion of the lower jaws, it is probable that they may have belonged to the same animal; and if so, as the portions of the head correspond in size with those of the head of a crocodile six or seven feet in length, but the acetabular cavity with that of a crocodile twenty-five feet in length, then the hinder extremities of the *Labyrinthodon* must have been of disproportionate magnitude compared with those of existing Saurians, but of approximate magnitude with some of the living anourous Batrachians. That such a reptile, of a size equal to that of the species whose remains have just been described, existed at the period of the formation of the New Red Sandstone, is abundantly manifested by the remains of those singular impressions to which the term *Cheirotherium* has been applied. Other impressions, as those of the *Cheirotherium Hercules*, correspond in size with the remains of the *Labyrinthodon Salamandroides*, which have been discovered at Guy's Cliff. The head of a femur from the same quarry in which the ilium was found exactly fits the acetabulum or the articular cavity of that bone. The two toe-bones, or terminal phalanges, resemble those of Batrachians in presenting no trace of a nail, and from their size they may be referred to the hind-feet of the *L. pachygnathus*.

Thus, all these osseous remains from the Warwick and Leamington sandstones agree with each other and with the fossil remains of the great *Mastodonsaurus Salamandroides* of the German keuper in their essentially Batrachian nature. Now it has been suggested by more than one Palæontologist that the impressions of the *Cheirotherium* may have been the foot-prints of a Batrachian; but, in consequence of the peculiarities of the impressions, it is obvious that the animal must have been quite distinct in the form of its feet from any known Batrachian or other reptile. In the attempt to solve the difficult problem of the nature of the animal which has impressed the New Red Sandstone with the Cheirotherian foot-prints, we cannot overlook the fact that we have in the *Labyrinthodon* also a Batrachian reptile, differing as remarkably from all other Batrachians, and from every other reptile in the structure of its teeth: both the footsteps and the fossils are, moreover, peculiar to the New Red Sandstone; and the hypothesis that the footsteps of the *Cheirotherium* are those of the *Labyrinthodon*, which I have proposed in my Memoir read before the Geological Society, may be allowed to be supported by more facts than had before been brought to bear upon the question.

Labyrinthodon scutulatus.—The remains, to which this specific designation has been applied, composed a closely and irregularly aggregated group of bones imbedded in sandstone, and manifestly belonging to the same skeleton;

they consist of four vertebræ, portions of ribs, a humerus, a femur, two tibiæ, one end of a large flat bone, and several small osseous, dermal scutes. The mass was discovered in the new red sandstone at Leamington, and was transmitted to me by Dr. Lloyd in the summer of 1840.

The vertebræ present biconcave articular surfaces similar to those of the other species. In two of them, the surfaces slope in a parallel direction obliquely from the axis of the vertebræ, as in the dorsal vertebræ of the frog, indicating an habitual inflexion of the spine, analogous to that in the humped back of the frog. The neurapophyses are anchylosed to the vertebral body. The spinous process rises from the whole length of the middle line of the neurapophysial arch, and its chief peculiarity is the expansion of its elongated summit into a horizontally flattened plate, sculptured irregularly on the upper surface. A similar flattening of the summit of the elongated spine is exhibited in the large atlas of the toad. The body of the vertebræ agrees with that of the *L. leptognathus*. The humerus is an inch long, regularly convex at the proximal extremity, and expanded at both extremities, but contracted in the middle. A portion of a somewhat shorter and flatter bone is bent at a subacute angle with the distal extremity, and resembles most nearly the anchylosed radius and ulna of the Batrachia.

The femur wants both the extremities; its shaft is subtrihedral and slightly bent, and its walls are thin and compact, including a large medullary cavity. The tibiæ are as long, but thicker and stronger than the femur. They had lost their articular extremities, but exhibited that remarkable compression of their distal portion which characterizes the corresponding bone in the Batrachia: they likewise have the longitudinal impression along the middle of the flattened surface. The length of the more perfect shaft is 2 inches 1 line.

With respect to the osseous dermal scuta, though they form a striking instance of the Crocodilian affinities of the Leamington fossil, yet as these detached superficial bones are the most liable to be separated from the fragmentary skeleton of the individual they once clothed, the negative fact of their not having been found associated with the remains of the *Labyrinthodon* in other localities, proves nothing in regard to a difference of dermal structure between the Leamington and Warwick species. Indeed no anatomist can contemplate the extensive development and bold sculpturing of the dermal surface of cranial bones in the *Labyrinthodon pachygnathus* and *L. leptognathus* without a suspicion, that the same character may have been manifested in bony plates of the skin in other parts of the body. Admitting for a moment this structure to be proved, to what extent, it will be asked, does it affect the claims of the *Labyrinthodon* to be admitted into the order of Batrachians, in which every known species is covered with a soft, lubricous and naked integument, without scales or scuta? In reply, I have observed*, that the skin is the seat of variable characters in all animals; and, if considered apart from the modifications of the osseous and dental systems, is apt to mislead the naturalist who is in quest of the real affinities of a species: thus we have in the Trionyx an example of a soft-skinned animal among Chelonian reptiles.

The following are the names of the species of extinct Reptiles in the order in which they are described in the second and concluding part of the Report:—

Order Enaliosauria.

Pliosaurus brachydeirus, Owen.
Pliosaurus trochanterius, Owen.

* Geological Proceedings, January 1841.

Order Crocodilia.

Crocodilus Spenceri, Buckland.
Suchosaurus cultridens, Owen.
Goniopholis crassidens, Owen.
Teleosaurus Chapmanni, König.
Teleosaurus Cadomensis, Geoffroy.
Teleosaurus asthenodeirus, Owen.
Steneosaurus brevirostris (rostro-minor), Geoffroy.
Poikilopleuron Bucklandi, Deslongchamps.
Streptospondylus Cuvieri, Owen.
Streptospondylus major, O.
Cetiosaurus brevis, O.
Cetiosaurus brachyurus, O.
Cetiosaurus medius, O.
Cetiosaurus longus, O.

Order Dinosauria.

Megalosaurus Bucklandi, Cuvier.
Hylæosaurus armatus, Mantell.
Iguanodon Mantelli, Cuvier.

Order Lacertilia.

Mosasaurus Hoffmanni, Conybeare.
Leiodon anceps, Owen.
Raphiosaurus subulidens, Owen.
Lacerta, sp. ind., Eocene.
Lacerta, sp. ind. (allied to *Scincus*), Oolite.
Rhynchosaurus articeps, Owen.
Thecodontosaurus antiquus, Riley and Stutchbury.
Palæosaurus cylindrodon, Riley and Stutchbury.
Palæosaurus platyodon, Riley and Stutchbury.
Cladyodon Lloydii, Owen.

Order Pterosauria.

Pterodactylus macronyx, Buckland.
Pterodactylus, sp. ind.

Sauria Incertæ Sedis.

Polyptychodon, Owen.
Rysosteus, Owen.

Order Chelonia.

Testudo Duncani, Owen.
Testudo, sp. ind. Oolite.
Emys testudiniformis, O.
Platemys Bowerbankii, O.
Platemys Bullockii, O.
Platemys Mantelli, Cuvier.
Tretosternon punctatum, O.
Emys, sp. ind. Kimmeridge Clay.
Emys, sp. ind. New Red Sandstone.
Trionyx, sp. ind.
Chelone planiceps, O.
Chelone obovata, O.

Chelone, sp. ind. Wealden.
Chelone pulchriceps, O.
Chelone Benstedi, Owen.
Chelone longiceps, O.
Chelone breviceps, O.
Chelone convexa, O.
Chelone subcristata, O.
Chelone latiscutata, O.

Order Ophidia.

Palæophis toliapicus.

Order Batrachia.

Labyrinthodon Salamandroides, Owen.
Labyrinthodon leptognathus, O.
Labyrinthodon pachygnathus, O.
Labyrinthodon ventricosus, O.
Labyrinthodon scutulatus, O.

SUMMARY.

A retrospective glance at the catalogue of Reptiles which formerly existed on that portion of the earth's surface constituting the present small island of Britain, and which are now extinct, must call forth such novel and surprising reflections on the dealings of Providence with the animated beings of this planet, as may well lead, in the first place, to a questioning of the truth of the affirmations with which the present summary commences. Did the numerous, strange, and gigantic representatives of the several orders of Reptiles actually at any time live and move and propagate their kind in the localities where their bones are now so abundantly found? Are not these bones the relics rather of antediluvian creatures, which perished in the great historical Catastrophe of Water, and have been washed from latitudes suitable to their existence to more northern shores? Are the British Fossil Reptiles actually extinct, and may not some living representatives of the Labyrinthodons, Enaliosaurs, Dinosaurs, &c., still remain to be discovered in those warmer regions where alone large species of reptiles are now known to exist?

Such questions and explanations of the phænomena which are the subject of the present Report will be most likely to suggest themselves to those who are not conversant with the truths of Geology, and who may never have been eye-witnesses of the circumstances under which fossil bones of reptiles are found.

In many cases these circumstances are so opposed to any that can be conceived to have been produced by the operation of a superincumbent bed of waters upon the present surface of the earth during a period of less than one year, that the earliest observers to whom the operations of a temporary general deluge suggested the first explanation of the appearance of the remains of a large and strange animal, were irresistibly led to the conviction that the conditions under which such fossil animal was found were wholly inexplicable on the supposition of its carcase having been left by the retiring waters of a flood. Thus the good Quaker of Whitby, in his letter to Dr. Fothergill, recounting the discovery of the extinct species of Crocodile that now bears his name (*Teleosaurus Chapmanni*), says, "The bones were covered five or six feet with the water every full sea, and were about nine or ten yards from the cliff, which is nearly perpendicular, and about sixty

yards high, and is continually wearing away by the sea washing against it: and, if I may judge by what has happened in my own memory, it must have extended beyond these bones less than a century ago. There are several regular strata or layers of stone, of some yards thickness, that run along the cliff nearly parallel to the horizon and to one another. I mention this to obviate an objection, that this animal may have been upon the surface, and in a series of years may have sunk down to where it lay, which will now appear impossible, at least when the stones, &c. have had their present consistence*."

It must be obvious, indeed, that the regular succession of horizontal layers, —"beginning from the top, of earth, clay, marble, stones, both hard and soft, of various thicknesses, till it comes down to the black slate or alum rock†,"— mounting to the height of near two hundred feet above the petrified skeleton, could not have been the result of the deposit of a temporary overflow of diluvial waters continuing for a few months, supposing even those waters to have been thickly charged with the ruined surface of the old earth. Succession of strata, as of all other phænomena, must take place in successive periods of time; the hundredth layer of lias, counting downwards, which contained the skeleton of the strange Crocodile, must once have been the uppermost, and some time must have elapsed between the deposition of that stratum with its organized contents and the deposition of the succeeding layer above.

If the fossilized bones of the animals described in the present memoir had been drifted to this island by a flood, they would be found mingled together in the superficial strata usually termed 'diluvial,' and would characterize no particular formation or locality. But the reverse of this is the fact; and it is the cumulative evidence of the limitation of certain genera to particular formations that gives its chief value to the present class of researches.

In the most superficial fossiliferous deposits which indicate the last operation of a body of water, either frozen or fluid, upon the surface of the British islands, no remains of reptiles have come under my observation. Cuvier alludes to a single bone of a crocodile said to have been found associated with the usual fossils of the drift or diluvium at Brentford‡: but no other evidence of any other species or genus of Reptile, which is now confined to warmer regions of the globe, has yet been recognized in the British strata called diluvial, or in any that are more recent than the oldest Tertiary formations.

In these Eocene beds, accumulated in some localities to the thickness of three hundred feet and upwards, the remains of crocodiles, tortoises, trionyxes, turtles, and large serpents, are more or less common. These fossils severally exhibit well-marked and unequivocal specific differences when compared with the bones of their known existing congeners; but their osteology does not present any modifications of generic value. The nearest approach to this degree of deviation occurs in the Eocene Chelonian Reptiles, as in that species of turtle from Sheppey, which combines the jaws of a Trionyx with the bony helmet of a Turtle, and presents an extent of ossification of the buckler nearly equalling that of an Emys. The Eocene Crocodile exhibits all the characters of the osseous and dental systems which distinguish the genus as restricted in the latest systems of Erpetology; and whilst it cannot be identified with any known species, most resembles, not the commonest and nearest existing Crocodile, as that of the Nile, but a rarer and more remote one, viz. the *Crocodilus Schlegelii* of Borneo. Not any species of Reptile of the Tertiary strata has been discovered in the chalk upon which those strata immediately rest.

* Philosophical Transactions, 1758, p. 688. † Ibid., p. 789.

‡ Dr. Buckland has suggested to me that this bone was probably washed out of the clay beneath the diluvium.

A small lizard, closely corresponding in vertebral structure with existing species, but differing in its dentition; and a gigantic marine species (*Mosasaurus*), which is the first, in the present descending survey, to offer osteological and dental combinations wholly unknown in existing Saurians,—constitute the representatives of the Lacertian order in the cretaceous beds, which form the most recent of the secondary deposits.

In tracing upwards the extinct Reptiles we find that the union of the vertebræ by a hinder ball received into an anterior cup, a structure which, with an insignificant exception—the Gecko—prevails throughout the Saurian order as it now exists, commences with the Lacertian Reptiles which perished during the deposition of the chalk, and, in the Crocodilian and Ophidian Reptiles, is first found in the species which made their appearance during the deposition of the London clay.

Of the Crocodilian order I have yet seen no unequivocal representatives from the British chalk.

All the well-determined Chelonians of the cretaceous period are marine species, and are equally distinct, with the Lacertians, from those of the superimposed tertiary beds.

The most interesting fact which the Palæontology of the cretaceous period has yielded, with reference to the great Saurian division of the class of Reptiles, is the commencement, or rather the last appearance of the fossil remains of an order of Reptiles (*Enaliosauria*) now altogether extinct. I have determined portions of the lower jaw with teeth of a large species of *Ichthyosaurus* from the lower chalk between Folkstone and Dover, which is very closely allied to, if not identical with, the *Ichthyosaurus communis*. The femur of a large *Plesiosaurus* has been obtained from the chalk of Shakspeare's Cliff. Remains of more than one species of *Plesiosaurus* occur in the Gault, and are associated with the *Ichthyosaurus* in the greensand near Cambridge, and in the Kentish Rag near Maidstone.

In the greensand also we first meet with evidences of Reptiles exhibiting modifications of structure, especially of the locomotive extremities, as remarkable and as different from those of existing species as are presented by the *Enaliosauria*, but pointing as strongly to an adaptation for terrestrial life as does the Enaliosaurian structure to aquatic existence. The specimen of the unquestionably terrestrial Saurian here alluded to, viz. the *Iguanodon*, is the more remarkable in the subcretaceous marine strata, in consequence of its presenting the largest proportion of the connected skeleton of the same individual of this species that has hitherto been found.

Gigantic Crocodilian Reptiles, removed by generic modifications of structure from the Eocene and existing Crocodiles, now likewise begin to be indicated, as by the teeth of the *Polyptychodon* from the greensand quarry at Maidstone, and by the large bones of the extremities from the quarries of a corresponding stratum at Hythe.

The Chelonian from the greensand (*Chelone pulchriceps*) differs from the Eocene and all existing turtles in a very interesting modification of the anatomy of the cranium.

In the Wealden group of freshwater strata, the Enaliosaurian order continues to be represented by the *Plesiosaurus*, but no remains of the more strictly marine genus, *Ichthyosaurus*, have yet been discovered. This circumstance corresponds with the more strict adaptation for marine existence which the structure of the *Ichthyosaurus* presents, and corroborates the inference that the *Plesiosaurus* lived nearer the shore, and ascended estuaries. The re-appearance of the *Ichthyosaurus* in the chalk formations proves that it had continued to exist in the neighbouring ocean, and indicates, perhaps,

that the deposition of the cretaceous beds was related to the formation of the Wealden group by proximity of time as well as place. The terrestrial group of gigantic Reptiles receives in the Wealden an accession of two new genera, viz. *Hylæosaurus* and *Megalosaurus*; and the remains of both these, and especially of the *Iguanodon*, are so abundant, that the Wealden strata may be regarded as the metropolis of the Dinosaurian order *.

The amphibious Crocodiles might be expected, from their known habits at the present day, to have left abundant evidences of their remains in strata, which seem to have been deposited at the estuary or mouth of some great river; in a climate, indicated by its vegetable fossils to have been warmer or more equable than at present; and during a period of time which permitted the accumulation of 1000 feet of strata. Accordingly, the Crocodilian order of Reptiles has been found to be represented by several distinct genera in the Wealden formations.

Some new characters and modifications of structure might also have been anticipated in those Crocodilians which existed at a period antecedent to the deposition of about 1500 feet of cretaceous strata, which, again, preceded the formation of the whole series of superimposed tertiary and diluvial beds. Nevertheless, the remarkable modifications which all the Wealden Crocodilians present in the structure of their vertebræ, as compared with the Eocene and existing Crocodiles, could not have been anticipated; and even now that they are ascertained by repeated observation, some of them still remain inexplicable in relation to any conjectural habits of the species, or hypothetical conditions under which they actually existed. We may understand why the ball-and-socket articulation of the vertebræ of the present amphibious Crocodiles frequenting dry land, should be exchanged for a joint having elastic substance included between two concave articular surfaces, as a structure better adapted to Crocodiles more habitually living and moving in water; but these Crocodiles with biconcave vertebræ are associated with others having plano-concave vertebræ, and also with a species having vertebræ joined by ball-and-socket articulations. And the difficulty is not diminished by the remarkable fact of the latter structure being the reverse of that in recent Crocodiles, the ball and the cup having changed places in the extinct *Streptospondylus*; and having assumed the position which they present in certain Sauroid fishes, and in the dorsal and cervical vertebræ of some of the herbivorous Mammalia.

The biconcave, plano-concave, and convexo-concave modifications of the vertebræ are not the only points in which the extinct Crocodilians of the Wealden strata differ from those of the London clay and from the existing species. The genus *Goniopholis*, for example, exhibits a remarkable development of its dermal armour, the large quadrangular scutes of which, interlocked by teeth received into depressions, are gigantic representations of the scales of some of the Ganoid fishes; while the smaller hexagonal and pentagonal scutes† were articulated together by marginal sutures, as in the dermal bony covering of the armadillo. The *Poikilopleuron* exhibits a medullary cavity in the body of the vertebræ, and a double origin of the spinous process. The *Suchosaurus* offers a very striking change in the form of the

* Dr. Mantell calculates that not less than seventy individuals of the *Iguanodon*, varying in age and magnitude, from the young just escaped from the shell to the mature animal, with a femur of more than a yard in length, have come under his examination; and he justly observes that "more than thrice that number have, in all probability, been destroyed by the workmen, and altogether eluded the observation of the Palæontologist."—See his Memoir in the Philosophical Transactions, 1841.

† These have been discovered since the first sheets of this Report went to press by my friend Mr. Holmes of Horsham, in the Wealden strata near that town.

teeth. The *Cetiosaurus* surpasses all modern Crocodiles in its enormous bulk, which almost rivals that of the Whales, its successors in the modern seas. The genus *Streptospondylus*, which, in repeating the ball-and-socket structure, offers the strange anomaly of an anterior position of the ball and a posterior one of the socket, makes its first appearance in the Wealden by a species which must have been little inferior to the *Cetiosaurus* in length.

The huge terrestrial Saurians of the Wealden deviate in so much greater a degree than the Crocodilians from the existing types, as to render the formation of a distinct order for their reception necessary.

It does not appear that any of the Chelonians of the Wealden period are specifically identical with those of the chalk. A new and singular osculant genus, *Tretosternon*, here represents the *Trionyces* of the Eocene freshwater or estuary formations. A new species of Turtle, with an Emydian form of shell, occurs in the Purbeck limestone; and the head of a turtle from the Portland stone, upon which the Purbeck beds immediately rest, exhibits the same distinction of the separate nasal bones, as does the skull of the turtle from the greensand, but combined with well-marked specific differences in other parts.

The Portland stone introduces us to the great Oolitic series, in which we lose sight of the *Iguanodon*, *Hylæosaurus*, *Goniopholis*, and *Suchosaurus*, but find that the *Megalosaurus*, *Poikilopleuron*, *Cetiosaurus*, *Streptospondylus*, and *Plesiosaurus*, are genera common to the Wealden and Oolitic periods.

Now also the genus *Ichthyosaurus*, which was represented by a single species in the chalk epoch, astonishes us by the number of individuals, and the great variety of specific modifications and varieties of form and bulk, under which it existed in the oolitic periods; especially in the older divisions of the oolite, as the lias. The number and variety of Plesiosaurian Reptiles are even more surprising, and the modifications of their skeleton being more marked and various, proportionally facilitate the determination of the species. The largest of these Plesiosaurian Reptiles deviates, indeed, so far from the typical structure of the genus as to merit subgeneric distinction. This subgenus, the *Pliosaurus*, characterizes the Kimmeridge and Oxford clays, but appears not to have existed at the period of the lower oolite.

In the place of the *Goniopholis* and *Suchosaurus*, the Crocodilian genera, *Steneosaurus* and *Teleosaurus*, with the subgenera, *Aelodon*, *Mystriosaurus*, *Macrospondylus*, &c. (separated, perhaps, without sufficient reason, from the first two typical genera of Amphicœlian Crocodiles), make their appearance in the oolitic strata, especially in the lower divisions. The long and narrow snouts, sharp and slender teeth, short fore-limbs, and imbricated scutation of these extinct Crocodilians, attest, with their vertebral structure, their adaptation to an aquatic life, and to the capture of a prey not more highly organized than fishes.

Some small species of Crocodilians and Lacertians have left a few bones of their extremities in the oolitic slate of Stonesfield; and a most singular order of Reptiles now makes its appearance, the skeleton of which exhibits a modification of the Lacertian type of structure closely analogous to that by virtue of which the mammalian Bat is endowed with the powers of flight. The flying Dragons, called *Pterodactyli*, were of small size, and are restricted, like the *Teleosauri* and *Steneosauri*, to the oolitic group. All the other genera are continued into the Wealden,—the *Poikilopleuron* and *Megalosaurus*, by identical species,—the other genera by species which are distinct from those of the oolite. The *Plesiosaurus* and *Ichthyosaurus* existed, as we have seen, as late as the deposition of the chalk. The analogy between the extinct Rep-

tiles and Fishes, in regard to the great proportion of genera which are common to the Wealden and Oolite, and the small proportion which is continued into the Cretaceous formations, offers a valuable corroboration of the subordinate character of the Wealden group as a member of the great Oolitic series.

No species or genus of Saurian represented by fossils from the Oolite has yet been discovered in older or lower strata in the British Islands. The *Rysosteus* is apparently confined to the bone-bed under the lias, which may be regarded as the oldest member of the Oolitic series in these islands.

The Reptiles of the Poikilitic strata exhibit deviations from the typical structure of the recent families, together with osculant characters joining groups now distinct, as great and even more anomalous than occur in any of the preceding extinct genera.

The *Rhynchosaurus* of the New Red Sandstone near Shrewsbury manifests Ornithic and Chelonian modifications, grafted upon an essentially Lacertian type of cranial structure; no approach even to the form of its extraordinary head being made by any other of the extinct members of the Saurian order. The vertebræ of the *Rhynchosaurus* differ from those of existing Lizards, Chelonians, and Birds, and combine the biconcave structure with the oblique processes and costal articulations of the vertebræ of recent Lizards.

The Labyrinthodonts of the same formation exhibit a different but an equally remarkable combination of characters, Crocodilian modifications being superinduced upon a fundamental organization of the Batrachian type. The structure of the teeth in this remarkable family, which is the most complex that has hitherto been met with in the whole animal kingdom, is unique in the class of Reptiles, and is but partially and comparatively feebly repeated in that of Fishes. It is highly probable that the modifications of the locomotive extremities were as peculiar as the dental characters, if we may judge from the foot-prints of the so-called *Cheirotherium*, to which the Labyrinthodonts alone have at present an equitable claim.

Finally, the *Palæosaurus* and other genera of the Magnesian conglomerate, like the so-called Monitors of Thuringia, are lizards which combined a thecodont type of dentition, with biconcave vertebræ, having the superadded peculiarity of a series of ventricose excavations in the bodies of the vertebræ for the spinal chord, instead of a cylindrical canal.

Below the New Red Sandstone system, notwithstanding that the older deposits, as the coal-measures, have been more thoroughly explored by man than any other geological formation, no trace of a vertebrate animal more highly organized than a fish, has been detected.

From this survey it is evident that many races of extinct reptiles have succeeded each other as inhabitants of the portion of the earth now forming Great Britain; their abundant remains, through strata of immense thickness, show that they existed in great numbers, and probably for many successive generations. Their coprolites prove that they fed upon organized beings coexisting with them and characterizing the same strata, but now equally extinct with their devourers.

To what natural or secondary cause, it may then be asked, can the successive genera and species of Reptiles be attributed? Does the hypothesis of the transmutation of species, by a march of development occasioning a progressive ascent in the organic scale, afford any explanation of these surprising phænomena? Do the speculations of Maillet, Lamarck and Geoffroy derive any support or meet with additional disproof from the facts already determined in the reptilian department of Palæontology?

A slight survey of organic remains may, indeed, appear to support their

views of the origin of animated species; but of no stream of science is it more necessary, than of Palæontology, to 'drink deep or taste not*.'

Of all vertebrated animals, the Reptiles form the class which is least fixed in its characters, and is most transitional in its range of modifications; the lowest organized species are hardly distinguishable from fishes, and the highest manifest so great an advance in all the important systems of their organism, that naturalists are not yet agreed as to whether reptiles ought to remain in one class or form two. Reptiles are, besides, the only class of vertebrate animals in which certain species undergo, after birth, a metamorphosis as singular and extreme as in insects.

If the progressive development of animal organization ever extended beyond the acquisition of the mature characters of the individual, so as to abrogate fixity of species by a transmutation of a lower into a higher organization, some evidence of it ought surely to be obtained from an extensive and deep survey of that class of animals which, whilst intermediate in organization between fishes and mammals, prevailed most on the earth during the long periods that intervened between the time when the only vertebrate animals were fishes, and the tertiary and modern epochs when mammals have become abundant, and have almost superseded reptiles in the herbivorous and carnivorous departments of the economy of nature.

In accordance with this not unreasonable expectation, the reptiles of the Magnesian conglomerate and New Red Sandstone ought to have been organized according to the type of the most fish-like perennibranchiate Batrachians; and the Fishes of the older strata, if they tended to a higher stage of development, ought, upon achieving the passage to the Reptilian class, to have entered it at its lowest step.

It is true, indeed, that the most characteristic Reptilian remains of the New Red Sandstone do belong essentially, as by their double occipital condyle, their vomerine palatal bones and teeth, &c., to the Batrachian order; but had the Labyrinthodonts now existed, instead of ranking as the lowest members of that order, they would most unquestionably have been esteemed the highest. And, as in the existing diversified order of Batrachia, one family† represents Fishes, a second‡ Serpents, a third genus§ Chelonians, and a fourth‖ Lizards; so would the now lost Labyrinthodonts have formed Batrachian representatives of the highest order of Reptiles, viz. the Crocodilians. Here, therefore, we find the Batrachian making its first appearance under its highest, instead of its lowest or simplest conditions of structure. To use the figurative language of the transmutation theory, the Labyrinthodonts are degraded Crocodiles, not elevated Fishes.

But the hypothetical derivation of reptiles from metamorphosed fishes is more directly negatived by the fact, that the Batrachian type is not that under which reptiles make their first appearance in the strata which succeed the coal-measures. The Monitors of the Thuringian Zechstein are older than the Labyrinthodonts of the Keuper; and among British Reptiles, the theco-

* The following are the latest terms in which the transmutation-theory has been promulgated, as supported by Palæontology:—"The life of animals exhibits a continued series of changes, which occupy so short a period that we can generally trace their entire order of succession, and perceive the whole chain of their metamorphoses. But the metamorphoses of species proceed so slowly with regard to us, that we can neither perceive their origin, their maturity, nor their decay; and we ascribe to them a kind of perpetuity on the earth. A slight inspection of the organic relics deposited in the crust of the globe, shows that the forms of species, and the whole zoology of our planet, have been constantly changing, and that the organic kingdoms, like the surface they inhabit, have been gradually developed from a simpler state to their present condition."—Dr. Grant's Lectures on Comparative Anatomy, Lancet, 1835, p. 1001.

† Perennibranchiata. ‡ Ceciliadæ. § Pipa. ‖ Salamandra.

dont Lizards of the Magnesian conglomerate have equal claims to a more ancient origin.

The questions, which the unbiased collector of evidence bearing upon the fixity or mutability of species has next to resolve respecting these primæval Lizards, are, whether they appeared under the form of the low-organized species which one naturalist classes with *Sauria*, another with *Ophidia*, or whether they exhibit indications of having emerged, by progressive development of structure, from any lower organized pre-existing group of cold-blooded animals? To these inquiries the Palæontologist must reply, that the thecodont Lizards of the Zechstein and Magnesian conglomerates combine well-organized extremities, with teeth implanted in distinct sockets, instead of being soldered, as in frogs, to a simple alveolar parapet; and that therefore if they existed at the present day, they would take rank at the head of the Lacertian order, and not among the families most nearly allied to the inferior reptiles. Neither are the modifications of the skeleton of the Rhynchosaur from the New Red Sandstone such as indicated that singular Lacertian to have been derived from the Ophidian or Batrachian orders; but, on the contrary, they connect it more closely than any known recent species, with Chelonia and Birds.

The nearest approximation to the organization of fishes is made by the *Ichthyosaurus*, an extinct genus which appears to have been introduced into the ancient seas subsequent to the deposition of the strata inclosing the remains of the thecodont Lizards. The ichthyic characters of this genus of marine Saurians are not of a very important kind, being limited, like the modifications of the mammalian type in Whales, to a relationship with locomotion in water, while all the modifications of the skeleton which are connected with the respiratory, digestive or generative functions, are conformable with the highest or Saurian type of reptiles; such as the cranial anatomy, the large size of the intermaxillary bones excepted,—the dental structure, which corresponds with that of the posterior teeth in Alligators,—the articulation of the neurapophyses to the bodies of the vertebræ,—the complicated pectoral arch,—the sternum and complete abdominal cincture of ribs*, &c. The circle of numerous imbricated sclerotic bones reaches its maximum of development in the *Ichthyosaurus*; but this is an exaggeration of a structure feebly shadowed forth in some existing Saurians, and more strongly shown in Birds, rather than a repetition of the simple bony sclerotic cup in Fishes. By no known forms of fossil animals can we diminish the wide interval which divides the most sauroid of Fishes from an *Ichthyosaurus*.

This most extraordinary Reptile is a singular compound in which Ichthyic, Cetacean, and Ornithic characters are engrafted upon an essentially Saurian type of structure. The *Ichthyosaurus* is, therefore, just such a form of animal as might be expected, were specific forms unstable, to demonstrate a mutation of characters or some tendency towards a progressive development into a higher and more consistent type of organization. Nor is the field for testing the transmutation theory less ample than the subject is favourable. We have the opportunity of tracing the *Ichthyosauri*, generation after generation, through the whole of the immense series of strata which intervene between the new red sandstone and the tertiary deposits. Not only, however, is the generic type strictly adhered to, but the very species, which made its first abrupt appearance in the lowest of the oolitic series, maintains its characters unchanged and recognizable in the highest of the secondary strata. In the chalk formations, for example, the genus *Ichthyosaurus* quits the stage of existence

* This structure proves that the mode of generation of the *Ichthyosaurus* must have resembled that of the Crocodile, and not that of the Batrachians or Fishes.

as suddenly as it entered it in the lias, and with every appreciable osteological character unchanged.

Of the different species of the *Ichthyosaurus*, founded upon minor modifications of the skeleton, several appear contemporaneously in the strata where the genus is first introduced; and those which remain the longest manifest as little change of specific as of generic characters. There is no evidence whatever that one species has succeeded or been the result of the transmutation of a former species. The tenuirostral *Ichthyosaurus* existed at the same time, and under the same external influences, as the stronger and shorter jawed *Ichthyosaurus communis*; just as the tenuirostral *Delphinus Gangeticus* coexists at present with the short-jawed porpoise.

If the relative periods of existence of the different Enaliosaurian reptiles were not well ascertained, and room were allowed for conjecture as to their successive appearance on this planet, it would be as easy as seductive to speculate on the metamorphoses by which their organic framework, influenced by varying conditions, during a lapse of ages, might have been gradually modified, so as to have successively developed itself from an Ichthyosaur to a Plesiosaur, and thence to a Crocodile.

We may readily conceive, for example, the fish-like characters of the vertebral column of the *Ichthyosaurus* to have been obliterated by a filling-up of the intervertebral cavities through ossification of the intermediate elastic tissue, and the Plesiosaurian type of vertebra to be thus acquired. The normal digits of the fin might be supposed to become strengthened and elongated by more frequent reptation on dry land, and thus to cause an atrophy of the supernumerary fingers: phalanges of a more saurian figure might have been produced by the confluence of a certain number of digital ossicles: the head might be shortened by a stunted growth of the intermaxillary bones, and thus be reduced to Plesiosaurian proportions. The teeth might become more firmly fixed by the shooting of bony walls across their interspaces, as in the young Crocodiles. If we now elongate the bodies of the vertebræ, reduce some twenty pairs of anterior ribs to hatchet-bones, place the fore-paddles at a corresponding distance from the head, and the hind-paddles proportionally nearer the end of the tail, little more will be required to complete the transmutation of the Ichthyosaur into the Plesiosaur.

If next, in adaptation to a gradual change of surrounding circumstances, the jaws of the Plesiosaur became lengthened to the proportions of those of the tenuirostral Ichthyosaur, but at the expense of the maxillary, instead of the intermaxillary bones, preserving the socketed implantation of the teeth; if, to balance the elongation of the jaws the neck at the same time shrank to nearly its former Ichthyosaurian proportions, with some slight modifications of the Plesiosaurian type of the vertebræ; if a further development and a more complete separation of the digits of the fore and hind members were to take place, so that they might serve for creeping as well as swimming; if the exposure of the surface to two different media, and of the entire animal to perils of land as well as of sea, were to be followed by the ossification of certain parts of the skin, and the acquisition, by this change, of a dermal armour,—such we might conceive to be the leading steps in the transmutation of the Plesiosaur into the Teleosaur.

And if the three forms of extinct Saurians, whose changes of specific and generic characters have thus been speculated on, had actually succeeded each other in strata successively superimposed in the order in which they have here been hypothetically derived from one another, some colour of probability might attach itself to this hypothesis, and there would be ground for searching more closely into the anatomical and physiological possibilities of such

transmutations. *Ichthyosaurus*, *Plesiosaurus* and *Teleosaurus* are, however, genera which appeared contemporaneously on the stage of vital existence: one neither preceded nor came after the other. How the transmutation theory is to be reconciled to these facts is not obvious; nor to these other, viz. that the Teleosaur ceases with the oolite, while the Ichthyosaur and Plesiosaur continue to co-exist to the deposition of the chalk, and disappear together alike unchanged; the Ichthyosaur manifesting as little tendency to develop itself into a Plesiosaur, as this to degrade itself into the more fish-like modification of the Enaliosaurian type.

If it were urged that the *Streptospondylus*, or Crocodile with ball-and-socket vertebræ, of which the remains occur in later secondary strata, when the Teleosaur had ceased to exist, might be a modification of the apparently extinct amphicœlian Crocodile, in which the vertebræ had undergone a progressive development, analogous to that by which the biconcave joints of the vertebræ of the Tadpole are actually converted into the ball-and-socket joints of those of the mature Frog, the facts of both geology and anatomy again oppose themselves to such an hypothesis: for the remains of the *Streptospondylus* occur likewise in the Whitby lias, which is the earliest formation characterized by remains of the *Teleosaurus*; and the modifications of the vertebral structure, by which the *Streptospondylus* differs from its ancient contemporary, and which it retains unaltered throughout the whole series of oolitic strata, is no approximation to the ball-and-socket structure of modern Crocodiles which first appears in the *Mosasaurus* and the Eocene Crocodiles, but is the very reverse. As reasonably might we infer that the Teleosaur was an intermediate form between the *Streptospondylus* and modern Crocodiles, and that the anterior ball had first subsided, and a sub-biconcave type of vertebræ had been produced before the posterior ball, which characterizes the vertebræ of recent Crocodiles, was finally developed.

If the present species of animals had resulted from progressive development and transmutation of former species, each class ought now to present its typical characters under their highest recognized conditions of organization: but the review of the characters of fossil Reptiles, taken in the present Report, proves that this is not the case.

No reptile now exists which combines a complicated and thecodont dentition with limbs so proportionally large and strong, having such well-developed marrow bones, and sustaining the weight of the trunk by synchondrosis or anchylosis to so long and complicated a sacrum, as in the order *Dinosauria*.

The Megalosaurs and Iguanodons, rejoicing in these undeniably most perfect modifications of the Reptilian type, attained the greatest bulk, and must have played the most conspicuous parts, in their respective characters as devourers of animals and feeders upon vegetables, that this earth has ever witnessed in oviparous and cold-blooded creatures. They were as superior in organization and in bulk to the Crocodiles that preceded them as to those which came after them.

There is not the slightest ground for affirming that the procœlian Gavial of the present day is in any respect more highly organized than the opisthocœlian Gavial of the oldest lias. If the differences of vertebral structure in these Crocodilians were contrasted, in reference to their relative approximation to the vertebral structure of the higher animals, the resemblance of the ball-and-socket joints of the spine of the *Streptospondylus* to those of certain mammals would give precedence in organic perfection to the primæval Gavial.

If, therefore, the extinct species, in which the Reptilian organization culminated, were on the march of development to a higher type, the *Megalo-*

saurus ought to have given origin to the carnivorous mammalia, and the herbivorous should have been derived from the *Iguanodon*. But where is the trace of such mammalia in the strata immediately succeeding those in which we lose sight of the relics of the great Dinosaurian Reptiles? Or where, indeed, can any mammiferous animal be pointed out whose organization can by any ingenuity or licence of conjecture, be derived without violation of all known anatomical and physiological principles, from transmutation or progressive development of the highest reptiles?

If something more than a slight inspection be bestowed upon the organic relics deposited in the crust of the globe, we learn that the introduction of mammalia on that crust is independent of the appearance of the highest forms of Reptiles. The small insectivorous mammals of the lower oolite* are contemporary with the most ancient Dinosaur, and are anterior to the *Iguanodon*.

The period when the class of Reptiles flourished under the widest modifications, in the greatest number and of the highest grade of organization, is past; and, since the extinction of the Dinosaurian order, it has been declining. The Reptilia are now in great part superseded by higher classes: Pterodactyles have given way to Birds; Megalosaurs and Iguanodons to carnivorous and herbivorous mammalia; but the sudden extinction of the one, and the abrupt appearance of the other, are alike inexplicable on any known natural causes or analogies.

New species, genera, and families of Reptiles have constantly succeeded each other, since the earliest periods in which the remains of this class can be discerned; but the change has been, upon the whole, from the complicated to the simple.

The Batrachian order, which is first indicated by the large and powerful Crocodiloid *Labyrinthodonts*, has dwindled down to the diminutive and defenceless Anourans and the fish-like Perennibranchians. The Saurian order was anciently represented by Reptiles manifesting the Crocodilian grade of organization under a rich variety of modifications and with great development of bulk and power: it has now subsided into a swarm of small Lacertians, headed by so few examples of the higher or loricate species, that it is no marvel such relics of a once predominating group should have found a humble place in Linnæus's Catalogue of Nature as coordinate members of the genus *Lacerta*.

Nevertheless some general analogies may be traced between the phænomena of the succession of Reptiles as a class, and those observed in the development of an individual reptile from the ovum. Thus the Embryonic structure of the vertebræ of the existing Crocodiles accords with the biconcave type; and this is exchanged, in the development of the individual as in the succession of species, for the ball-and-socket structure as the latest condition.

The almost universal prevalence of the more or less biconcave structure of the vertebræ of the earlier reptiles thus establishes a most interesting analogy between them and the earlier stages of growth of existing reptiles.

A similar analogy has been pointed out by M. Agassiz, between the heterocercal fishes, which exclusively prevail in the oldest fossiliferous strata, and the embryos of existing homocercal fishes, which seem to pass through the heterocercal stage.

The superior number of loricate Reptiles, and the more complete development of the dermal armour in the Crocodilian genera *Steneosaurus*, *Teleo-*

* For the proof of the often doubted mammalian character of the *Thylacotherium* and *Phascolotherium* of the Stonesfield slate, the reader is referred to the Memoirs in the Sixth Volume of the Second Series of the Geological Transactions, pp. 47–58.

saurus, *Goniopholis*, &c., of the Oolitic and Wealden strata, corresponds with the prevalence of the well-mailed Ganoid order of fishes in the same formations.

The fossil reptiles, like the fossil fishes, approximate nearest to existing species in the tertiary deposits, and differ from them most widely in strata whose antiquity is highest.

Not a single species of fossil reptile now lives on the present surface of the globe.

The characters of modern genera cannot be applied to any species of fossil reptile in strata lower than the tertiary formations.

No reptile, with vertebræ articulated like those of existing species, has been discovered below the chalk.

Some doubt may be entertained as to whether the *Ichthyosaurus communis* did not leave its remains in both oolitic and cretaceous formations, but with this exception no single species of fossil reptile has yet been found that is common to any two great geological formations.

The evidence acquired by the researches which are detailed in the body of this Report, permits of no other conclusion than that the different species of Reptiles were suddenly introduced upon the earth's surface, although it demonstrates a certain systematic regularity in the order of their appearance. Upon the whole they make a progressive approach to the organization of the existing species, yet not by an uninterrupted succession of approximating steps. Neither is the progression one of ascent, for the Reptiles have not begun by the perennibranchiate type of organization, by which, at the present day, they most closely approach fishes; nor have they terminated at the opposite extreme, viz. at the Dinosaurian order, where we know that the Reptilian type of structure made the nearest approach to Mammals.

Thus, though a general progression may be discerned, the interruptions and faults, to use a geological phrase, negative the notion that the progression has been the result of self-developing energies adequate to a transmutation of specific characters; but, on the contrary, support the conclusion that the modifications of osteological structure which characterize the extinct Reptiles, were originally impressed upon them at their creation, and have been neither derived from improvement of a lower, nor lost by progressive development into a higher type.

The general progressive approximation of the animal kingdom to its present condition has been, doubtless, accompanied by a corresponding progress of the inorganic world; and thus, the differences which comparative anatomy demonstrates to have existed between the vertebrated inhabitants of the secondary epochs of the geological history of the earth, and the tertiary and present periods, form legitimate grounds for speculation, not only on the essential nature and causes of those differences, but upon the progressive changes to which our planet and its atmosphere may have been subject. For whether there had been grounds for regarding the organic phænomena of primæval times as earlier stages in the progressive development and transmutation of species, or whether, as the closest investigation of these phænomena seems to demonstrate, they have been the result of expressly created and successively introduced species,—they naturally lead the physiologist to speculate on the varying conditions of the surrounding media to which such organic differences may have related.

Now Reptiles mainly and essentially differ from Birds and Mammals in the less active performance of the respiratory function, and in a lower and simpler structure of the lungs and heart, whereby they become, so to say,

less dependent on the atmosphere, or oxygen, for existence. From their extraordinary prevalence in the secondary periods, under varied modifications of size and structure, severally adapting them to the performance of those tasks in the economy of organic nature which are now assigned to the warm-blooded and quick-breathing classes, the physiologist is led to conjecture that the atmosphere had not undergone those changes, which the consolidation and concentration of certain of its elements in subsequent additions to the earth's crust may have occasioned, during the long lapse of ages during which the extinction of so large a proportion of the Reptilian class took place. And if the chemist, by wide and extended views of his science in relation to geology and mineralogy, should demonstrate, as the botanist, from considerations of the peculiar features of the extinct Flora has been led to suspect, that the atmosphere of this globe formerly contained more carbon and less oxygen than at present, then the anatomist might, *à priori*, have concluded that the highest classes of animals suited to the respiration of such a medium must have been the cold-blooded fishes and reptiles.

And besides the probability of such a condition of the zoological series being connected with the chemical modifications of the air, the terrestrial Reptiles, from the inferior energy of their muscular contractions, and still more from the greater irritability of the fibres and power of continuing their actions, would constitute the highest organized species, best adapted to exist under greater atmospheric pressure than operates on the surface of the earth at the present time.

Through such a medium approaching in a corresponding degree to the physical properties of water, a cold-blooded animal might even rise above the surface and wing its heavy flight, since this would demand less energetic muscular actions than are now requisite for such a kind of locomotion; and thus we may conceive why the atmosphere of our planet, during the earlier oolitic periods, may have been traversed by creatures of no higher organization than Saurians. If we may presume to conjecture that atmospheric pressure has been diminished by a change in the composition as well as by a diminution of the general mass of the air, the beautiful adaptation of the structure of birds to a medium thus rendered both lighter and more invigorating, by the abstraction of carbon and an increase of oxygen, must be appreciable by every physiologist. And it is not without interest to observe, that the period when such change would be thus indicated by the first appearance of birds in the Wealden strata*, is likewise characterized by the prevalence of those Dinosaurian Reptiles which in structure most nearly approach Mammalia, and which, in all probability, from their correspondence with Crocodiles in the anatomy of the thorax, enjoyed a circulation as complete as that of the Crocodile when breathing freely on dry land†.

* Foot-prints alone, like those termed 'Ornithichnites,' observed in the New Red Sandstone of Connecticut, are insufficient to support the inference of the possession of the highly developed organization of a bird of flight by the creatures which have left them. The Rhynchosaur and biped Pterodactyles already warn us how closely the ornithic type may be approached without the essential characters of the Saurian being lost. By the Chirotherian Ichnolites we learn how closely an animal, in all probability a Batrachian, may resemble a pedimanous mammal in the form of its foot-prints.

The degree in which flying insects can resist noxious gases, which would be quickly fatal to the warm-blooded Vertebrates, invalidates the objection to a progressive change of atmosphere having accompanied the prevalence of quick-breathing animals, which might be suggested by the *Libellulæ* of the lias and by the oolitic Beetles.

† All existing Reptiles, which have the ribs at the anterior part of the thorax united by a head and tubercle to the centrum and neurapophysis of the vertebræ, have a heart with two distinct ventricles as well as two auricles. The contiguous aortæ arising from the two ventricles intercommunicate by an aperture so placed as to be covered by the sigmoid valves

The first indications of the warm-blooded classes, it might be anticipated, would appear, if introduced into the Reptilian era, under the form of such small insectivorous mammals, as are known at the present day to have a lower amount of respiration than the rest of the class; and the earliest discovered remains of mammalia, as, for example, those in the Stonesfield oolite, are actually the jaws of such species, with which are combined the characters of that order, Marsupialia, which is most nearly related to the oviparous Vertebrata.

The present speculations are, however, offered with all due diffidence; the collection of the evidence requisite for pursuing them to a semblance even of demonstration is only just begun, and they are thrown out with no other expectation of utility than as incentives to the chemical considerations of the nature and possibilities of such atmospheric changes as may be physiologically connected with the variations of organic nature made known by the researches of the anatomist.

A too cautious observer would, perhaps, have shrunk from such speculations, although legitimately suggesting themselves from the necessary relations between the organs and media of respiration; but the sincere and ardent searcher after truth, in exploring the dark regions of the past, must feel himself bound to speak of whatever a ray from the intellectual torch may reach, even though the features of the object should be but dimly revealed.

when blood is transmitted equally through them. When the amphibious Crocodile suffers an interruption in the pulmonary circulation by continued submersion, the aorta from the left ventricle, by the communication above mentioned, receives venous blood from the overcharged cavities of the right side of the heart; but when respiration is in full vigour on dry land, an undiluted stream of arterial blood is transmitted through the left aorta to the head and anterior extremities. The Dinosaurs, having the same thoracic structure as the Crocodiles, may be concluded to have possessed a four-chambered heart; and, from their superior adaptation to terrestrial life, to have enjoyed the function of such a highly-organized centre of circulation in a degree more nearly approaching that which now characterizes the warm-blooded Vertebrata.

ERRATA.

Page 64, 14 lines from bottom, *for* 'Cœlospondylian' *read* 'Amphicœlian.'
—— 67, 25 lines from top, *for* 'bifurcate' *read* 'biporcate.'
—— 88, after the 3rd line from top, insert 'with convexo-concave vertebræ.'
—— 104, 14 lines from bottom, *for* 'Clœospondylian' *read* 'Amphicœlian.